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November 1, 1979 - April 30, 1980

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NASA Grant NGL 25-001-054

Submitted To

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Office of Space and Terrestrial Application
Technology Transfer Division
Washington, D. C.

Submitted By

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May 1, 1980

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APPLICATION OF REMOTE SENSING TO STATE AND REGIONAL PROBLEMS

I. INTRODUCTION

The major purpose of the Remote Sensing Applications Program is to interact with units of local, State, and federal government and to utilize Landsat data to develop methodology and provide data which will be used in a fashion such that a concrete, specific action will be taken by the cooperating agency. The attainment of this goal is dependent upon identification of agency problems which are immediate in nature, and subject to at least partial solution through the use of remotely sensed data.

Other subsidiary objectives include the development of a trained staff from the faculty of Mississippi State University who are capable of attacking the varied problems presented by the respective State agencies; the training of students in various University academic courses at both the undergraduate and graduate levels; the dissemination of information and knowledge through workshops, seminars, and short courses; and the development of a center of expertise and an operational laboratory for training and assistance to cooperating agencies.

II. GENERAL PROGRAM PROGRESS

Within the past six months, three separate agencies have taken actions or made decisions based, to a large extent, on data supplied by applications projects. The Mississippi Natural Heritage Program has contracted with three botanists to visit 25 sites initially identified by Applications Program personnel as possible unique ecological communities (see Section III F). These sites were identified by Landsat and aircraft data and are located in the potential lignite mining area of Mississippi which extends from Quitman County in the northwest to Lauderdale and Kemper Counties in the southcentral part of the State.

Mr. Ray Gildea, Lowndes-Columbus Civil Defense Director, reports that, based upon new modeling efforts with the Lowndes County Landsat-Based Information System, the Lowndes County Board of Supervisors will probably initiate construction of a new fire substation as early as next year upon a location selected by the hazard-risk models (see Section III A). The Board further indicated that construction of two additional substations will take place in the future. All three sites were identified by the hazard modeling effort of Mr. Gildea and Program personnel.

Mr. Leroy Urie, President of the Harrison County Board of Supervisors, has stated that the Board is following up on recommendations made in the Beach Erosion Report, and has let a contract for an additional 5000 ft of beach to be treated in actively eroding areas (Section III C).

III. PROJECT PROGRESS REPORTS

A. Remote Sensing Applications in Land Use Planning - Lowndes County

Objective

To develop a Landsat-based data management system that will provide variables and data which can be used by the County Tax Assessor, the Civil Defense Director, and the Lowndes County Board of Supervisors, and for employment in the land use planning function by the Golden Triangle Planning and Development District and the Mississippi Research and Development Center.

Accomplishments

In response to a request by Mr. Ray Gildea, acting in his capacity of County Fire Coordinator, three new variables were added to the Lowndes County Landsat-Based Information System. A complete summary of past actions and present uses of the Information System is given in Appendix I, which represents a paper prepared by Mr. Gildea and presented at the 1980 Annual Meeting of the Association of American Geographers, Lexington, Ky. The excerpt reproduced below illustrates the most recent action taken by the Lowndes County Board of Supervisors.

> "In addition to using the new fire performance variables, models were created to identify prime growth areas where possible future demands for fire service may develop. Existing fire potential models were also determined by combining the following factors: the location of high and low density residential development, the location of major arterials, rail lines and crossings, the location of airports and major industries. This information was weighted and inte-

grated with fire occurrence data to set priorities for the locations of future fire substations. After manipulating service area boundaries based on past performance, future growth areas, the location of existing development, and transportation routes, departments were able to determine where service was satisfactory and where additional facilities might be needed.

As a result, three sites have been identified for substations. Members of the Board of Supervisors have indicated that construction might begin next year on the first of these sites. Hard-copy output depicting the fire variables was exhibited at Lowndes County Firemen's Appreciation Day ceremonies held in February, 1980. The cell based geo-information system advanced by Lowndes County officials for hazard vulnerability analysis provides a viable alternative to polygonal systems like the DIME geobase."

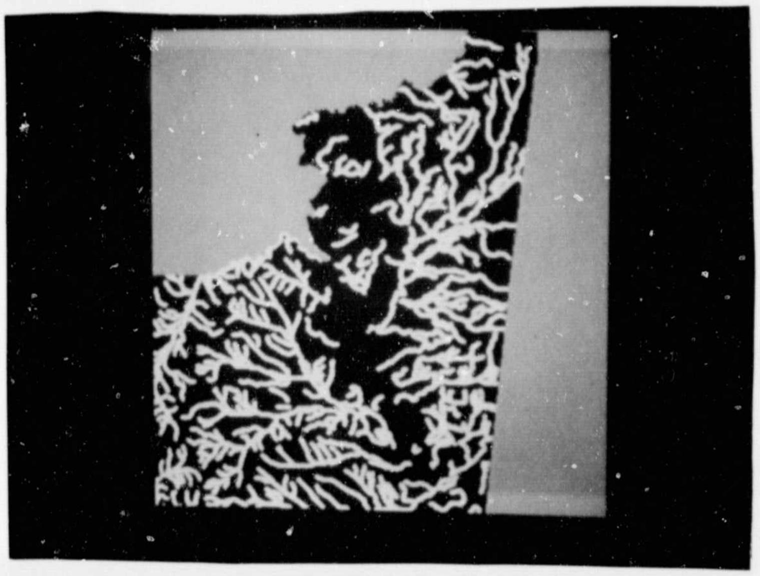

Figure 1. Areas within 1 cell of first, second and third order streams. Used in a flash flood prediction model.

Figure 1 represents one of the variables which was utilized in the flash flood prediction models developed for Hurricane

Bob. The product of this analysis illustrates the area within 467 feet of first, second or third order streams. The next two figures illustrate the flexibility of the interactive system in updating variables. Figure 2 shows the original soil associations and the area to be updated in yellow.

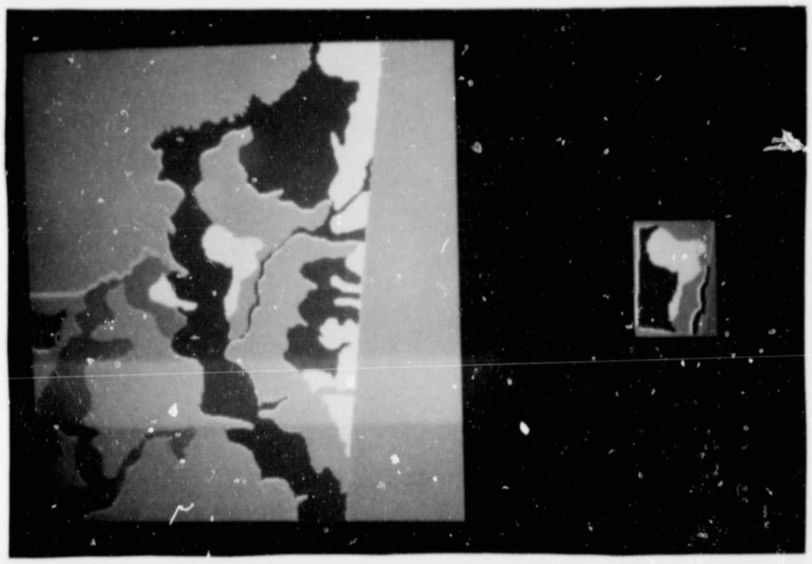

Figure 2. The original variable of Soil Associations in Lowndes County.

After the area for change has been selected, any image segment within this area can be given a new value and the result can be placed back in the original image by a "replace" or an "add" command. Figure 3 shows the update area in dark blue.

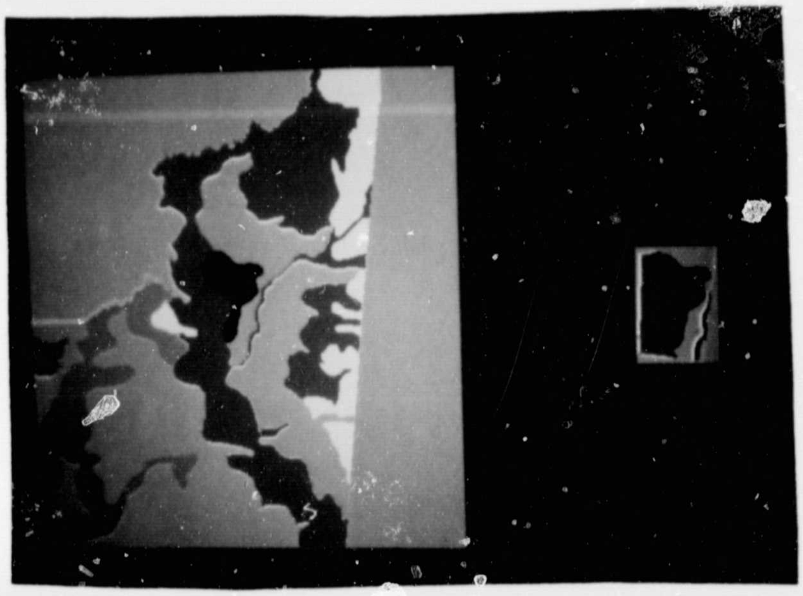

Figure 3. A corrected version of the Soil Associations variable. The area changed is in dark blue.

Current Status

Work is continuing on the development of more detailed data bases for several small demonstration areas.

Plans

A CCT of recent date will be obtained, classified, and the updated land cover information will replace the older cover data. County and Federal officials will continue to be contacted and encouraged to utilize the system in the decision-making process.

B. Applications of Landsat Data to Strip Mine Inventory and Reclamation

Objective

The objective of this project is to provide the Alabama Surface Mining Reclamation Commission and the Geological Survey of Alabama with the software and interpretative techniques for monitoring strip mine occurrence and reclamation activities. The results will also be provided to the Mississippi Geological, Economic, and Topographic Survey - the State agency which is responsible for administering the surface mining law in Mississippi.

Accomplishments

The decision tree classifier still awaits testing and validation with respect to temporal extension. As mentioned in the 12th Semi-Annual Progress Report, the CCT of March 6, 1979, was found to be faulty and had to be returned to EROS.

A CCT of March 15, 1979, was obtained. After some initial problems resulting from format changes, the tape was input into the decision tree classifier with very poor results. The results were so poor that a detailed analysis of the data on the new CCT was undertaken. It is the opinion of J. L. Solomon that the data on the tape are in error. EROS was contacted regarding this concern; they could find no "error" and concluded that the master tape appeared to be in good order.

The following examples provide some evidence as to the concern for the information on the CCTs:

Table 1
Comparison of Signatures of Forest and Water Between 1977 and 1979 CCTs

FOREST (SIGNATURES) "TYPES" - MEAN VECTORS FOR 3 SUBCLASSES.

	Band 4	Band 5	Band 6	Band 7
Original CCT	16.21	10.74	13.05	6.61
	12.34	12.32	20.35	9.85
	17.55	12.94	18.23	9.67
"New" CCT	16.06	15.37	25.92	31.05
	15.63	15.12	22.03	26.79
	17.42	19.60	27.44	32.90

WATER (SIGNATURES) "TYPES" - MEAN VECTORS FOR 3 SUBCLASSES.

	Band 4	Band 5	Band 6	Band 7
Original CCT	14.89	12.05	8.09	1.40
	13.16	8.86	3.28	0.36
	18.36	11.68	7.79	2.23
"New" CCT	22.12	18.00	7.02	3.83
	21.11	18.15	11.38	8.59
	21.50	17.84	9.05	5.81

Climatological information for the week preceding March 15, 1979, indicates nothing that would account for these large reflectance changes (Note the behavior in Band 7 for the different forest classes).

A User's Manual has been prepared by Dr. Nancy Freeman of the Department of Mathematics, Mississippi State University. This guide permits the average user to carry out the process beginning with LARSYS format tape to a classified output (Appendix II).

Current Status and Future Plans

A new CCT has been acquired and is now being processed. It is felt that the final phase of this project can now be completed, and will result in one of the following actions being taken:

1. Transferring the software to the appropriate agencies for use in monitoring surface mine reclamation activity;
2. The classifier, as designed, does not allow for temporal extension, and this approach will be discontinued;
3. Redesigning the classifier in light of new information acquired during the testing and validation phase of the project.

C. Beach Erosion Control - Pass Christian

Objectives

The overall project objective is to apply remote sensing technology to the delineation of zones of high erosion along the Pass Christian Beach.

Specific objectives are:

1) To refine and adapt remote sensing techniques to identify and define those beach areas along the Mississippi Gulf Coast at Pass Christian, Mississippi, which are sources of wind-blown sand.

2) To develop automated procedures calibrated with ground truth information and meteorological data for estimating zones of sand movement origin.

3) To design sand stabilization or turbulence obstruction features which, when appropriately located on the beach, will reduce sand erosion, are aesthetically pleasing, and are consistent with tourist attraction and use and local commercial activities.

Accomplishments

As indicated in Semi-Annual Progress Report #12, a small test obstruction site was constructed in an actively eroding area of the beach indicated by project results. Based upon the stabilization achieved by this structure, the Harrison County Board of Supervisors has taken the following actions:

1) The beach maintenance procedure has been modified by changing times of maintenance, and by using different intensities of maintenance work in the eroding areas.

2) Although the Board now feels that their test section was too small, they have had sufficiently positive results to let a contract on an additional 5000 feet of obstruction installation and accompanying landscaping as indicated by the project recommendations.

Current Status

Inactive.

Future Plans

Contact with the Board of Supervisors will be maintained and encouragement provided to complete the study recommendations.

D. White-Tailed Deer Habitat Evaluation Using Landsat Data

Objectives

In order to provide a basis for sound natural resource management in Mississippi, the Mississippi Game and Fish Commission has initiated the development of a State-wide data base system which will be used to describe various components of Mississippi's ecosystems. The high priority of the white-tailed deer (*Odocoelius virginiana*) in the Commission's management policies dictates that various types of deer "habitat" be mapped and evaluated on a State-wide basis. These "habitats" will be delineated on the basis of several biophysical variables.

Because of its synoptic and temporal characteristics, Landsat multi-spectral scanner (MSS) data will be used as the basis for vegetative evaluation. Both supervised and unsupervised classification of the data will be performed to determine the most accurate and the most cost-effective means of mapping vegetation. Other variables used to evaluate deer habitat will be compiled from existing sources. All data will be configured in a computer-assisted data base to facilitate rapid and accurate habitat evaluation.

The project's objectives, in order of planned completion, are:

1. To determine those types of vegetative associations which are of significance in managing Mississippi's white-tailed deer.
2. To determine which of several analytical procedures are most effective in detecting these vegetation types using Landsat MSS data.

3. To configure this vegetation data, as well as other data pertinent for habitat evaluation, in a computer-assisted data base which will permit habitat description and evaluation.

Accomplishments

Construction of the habitat data base for the Tallahala Game Management Area (GMA) and analysis of Landsat Multi-spectral Scanner (MSS) data for land cover at Tallahala have been the major concerns of the project during the past 6 months.

Information concerning roads and trails, rights-of-way, streams and ponds, soils associations, and political boundaries has been configured in a habitat data base for the Tallahala GMA. This first data base will be completed as a demonstration of the technique as well as to test data base construction methods to be used for the other three study areas.

The variables were digitized from 1:24,000 scale base maps at a data base cell resolution of 2.5 acres (approximately 1 ha.) using the Numonics digitizer/Texas Instrument Silent 700 Data Terminal equipment of the Remote Sensing Applications Program. The data base is presently maintained on the Mississippi State University (MSU) Univac 1100/80 computer.

Fall 1978 (1 November) and winter 1979 (26 February) MSS data for Tallahala have been analyzed using the ISOCLS clustering processor and CLASSIFY classifier processor of the EOD-LARSYS image analysis package on the MSU Univac 1100/80 system.

Two approaches have been employed. Large blocks of the study area (3000-5000 acres) containing many vegetation types and small blocks (100-200 acres) containing single forest types have both been used as training fields in the ISOCLS clustering processor. This has been done for both fall and winter. Initial evaluation indicates that large samples work well in fall and smaller training fields work better in winter. The presence of foliage in the fall, as expected, makes MSS data from this season more effective in separating forest types than data from winter.

Digital terrain data (topographic) have been mapped from digital tapes (National Cartographic Information Center) for the Tallahala GMA. These data are presently on disk storage awaiting loading into the data base.

At the request of the Department of Wildlife and Fisheries, MSU, and the Texas Parks and Wildlife Department, a paper presenting an overview of the data base approach was given at the Third Annual Meeting of the Southeast Deer Study Group on 11 and 12 February 1980 at Stephen F. Austin State University, Nacogdoches, Texas. The text of this paper is presented in Appendix III.

Many favorable comments were received including several requests for documentation on our methods. These are being followed up at present.

Current Status

MSS data analysis for the Tallahala GMA comprises approximately 85% of the present efforts for the project. Use of the ISOCLS processor continues with adjustments to the clustering sensitivity and the size and number of training fields.

The results of each run are being evaluated by comparing the computer-generated maps with the map produced by air photo interpretation and field observations. Planning for additional image analysis, particularly unsupervised analysis and analysis using ratioed bands, is in progress.

Future Plans

Once the digital terrain data for the Tallahala GMA have been successfully configured in the data base, construction of data bases for the other study areas will begin. This should start in May 1980 and be completed in August or September 1980.

ISOCLS/CLASSIFY processing will continue on the data for the Tallahala area using spring and summer data. This should end in April 1980.

Unsupervised image analysis using the HINDU processor will begin shortly for Tallahala. This too will end in late April. A band ratioing approach is being considered for the Tallahala GMA. This will likely take the form of a 2-band ratio employing Band 5 plus Band 7.

At the end of April (1980) the most effective algorithm will be chosen based on the results of the Tallahala work, and used for the remaining sites.

Land cover maps for all four sites should be available in late May.

E. Remote Sensing Data Analysis Support Systems

Objectives

To effectively implement the remote sensing applications and projects of the Applications Program, particularly those involving the Landsat multispectral data, it is essential that reasonably sophisticated computer-based data processing and data analysis systems be developed. Considerable effort is required to develop new computer software, to adapt existing software, and to install needed hardware facilities. This is in addition to the operational data processing and data analysis needs of each demonstration project. Moreover, it is the objective of the Data Analysis Support System to provide the data collection and processing capabilities necessary to support the various demonstration projects, and to provide a low-cost operational center so that such projects can have a continuing input into the overall objective of the Applications Program.

Accomplishments and Current Status

Two graphic software systems are currently in use on the image processing system. Both programs are operating systems designed specifically for use on the Mississippi State color graphics system. The heart of the MSU system is the Data General 5130 Eclipse computer with 256 K bytes of main memory. The Eclipse drives a Lexidata 6400 image processing system and a Varian 4200 electrostatic plotter. One system is a Geographic Information System (GIS) and the other system is basically a data base manager.

The GIS is capable of displaying images from several different sources. The primary data source for the GIS is a LARSYS formatted tape which can be generated from Landsat CCT's on the 1100/80 computer at Mississippi State. The remaining data sources are files which are produced by the GIS. Many functions which are useful in manipulating images have been included in the GIS. These functions allow the capability of zooming, color and intensity modification, shifting, windowing, and algebraic and logical manipulation of images. The algebraic and logical operations include

1. addition
2. subtraction
3. multiplication
4. division
5. "AND"
6. "OR"
7. greater than
8. less than

The operands for the algebraic and logical functions are user defined images so that entire images may be combined in complex expressions using the eight given operations to produce a new image. As many as ten images may be combined in a single expression. In addition to the many functions available in the GIS, up to five additional user-defined functions may be easily incorporated into the system. A User's Manual is presented in Appendix IV.

A second system which has been implemented on the Mississippi State system is ba^ically a data base manager (DBM). The DBM system is capable of maintaining a data base containing any number of variables. New variables from any of a variety of sources (e.g., Landsat images, censor data, digitized maps) can be easily added to the data base. Aside from maintenance of the data base, the DBM system allows for logically combining and overlaying of data base variables on the image display. Currently, a data base containing 40 variables for Lowndes County, Mississippi, is being maintained by the DBM system. Appendix V contains a paper presented at the Southeast Region Chapter of The Association for Computing Machinery (ACM), and presents a detailed description of the data base manager. This paper won the Student Paper Competition at ACM.

Future Plans

Presently, all classification of Landsat data is done on the UNIVAC 1100/80 computer by the LARSYS and HINDU programs. That is, no classification program is presently operational on the Data General computer. Future plans include implementation of such a program on the Data General. Programs being considered for adaptation are the HINDU and the ELAS programs.

F. Discrimination of Unique Forest Habitats in Potential Lignite Areas of Mississippi

Objectives

The objectives of this project are: (1) to develop a cost-effective methodology using Landsat and aircraft data to discriminate areas of old growth hardwoods that do not exhibit signs of recent disturbance within Mississippi's lignite belt, and (2) to identify and map such areas and provide the information to botanists employed by the Mississippi Heritage Program.

Accomplishments

Interpretation of 1/250,000 scale Band 7 yielded areas of dissected terrain which, if they contained hardwood stands, would have a relatively high probability of containing undisturbed, old growth hardwood communities. The areas were digitized into a data base of the study area. Soil association data were also input. Due to the lateness of contract initiation, it was necessary to select flight areas before completion of the classification of the Landsat digital data. The classification is, however, proceeding; and after input to the data base, the original site selections will be verified and new sites proposed.

A total of 680, 1/24,000, color infrared images in 23 flight strips were acquired early in November 1979. These flights were centered on areas identified as high probability sites on the basis of manual interpretation of Band 7 and color composites of the project area. Two interpreters scanned the film and identified about 60 areas for more detailed analysis. Ground truth data were collected for several of the areas designated. A rating system from 1 = highly probable to 4 = low probability was devised. The system included stand size, area, proximity to cultural activity, and evidence of disturbance (grazing, logging) within the stand. Twenty five sites survived more detailed analysis, and these locations and designations were distributed to the appropriate botanists in their respective areas. These three botanists, representing Mississippi State University, Delta State University and the University of Mississippi have been contracted by the Heritage Program to inventory herbaceous vegetation on the sites identified by this project. This project is 100% funded by State and Department of the Interior monies.

Current Status

The classification of the Landsat CCT's covering the study area is proceeding, and the decision-tree classifier will be utilized in the final analysis.

Future Plans

The classified Landsat data will be input to the data base, and a model will be developed to locate potential areas of unique forest habitats. The software and results will be transferred to the Heritage Program upon completion.

G. Landsat Change Discrimination in Gravel Operations

Objectives

The objectives of this proposal are to: (1) develop methodology and computer software to effect temporal change detection in extent of gravel operations, and (2) perform the change detection analysis on a portion of the Loessial Bluffs from a point east of Greenwood to the Mississippi-Tennessee line.

Accomplishments

The ground truth has been collected for eight active gravel operations in the study area. A portion of the ground truth consisted of low altitude, 35 mm color infrared and color slides and prints of the areas (Figure 4). ISOCLS from the EOD-LARSYS package

Figure 4. J. J. Ferguson Mine, Grenada County #1. Active operations in cream colors, reclaimed areas on north end in central part of mine. February, 1980.

has been performed on the gravel operations as located on the graphics system. This project is 100% funded by the Mississippi Minerals Resources Institute (MMRI).

Current Status

Signatures for active gravel operations, water, bare soil, forest, pastures, and reclaimed areas are being generated.

Future Plans

When signatures selection is completed, the decision-tree classifier will be applied to the digital data corresponding to a date approximately two weeks prior to the initiation of the Reclamation Regulations.

When the areas of each active mine have been established, the MMRI will evaluate the results in an effort to determine if the Reclamation Regulations have been adequately followed.

H. Environmental Impact Modeling for Highway Corridors

Objective

The objective of this small project is to develop a cost-effective, accurate methodology for assessment of environmental impacts of alternative highway corridors.

Accomplishments

The data base for the Highway 78 Bypass Corridor in the vicinity of Tremont, Mississippi, has been completed, and it contains the following variables and subvariables:

Table 2
Highway 78 Bypass Data Base Variables

Variable 1 Surface Water		
Subvariable	0	None
	1	1st order stream
	2	2nd order stream
	3	3rd order stream
	4	Ox-bow lakes
	5	Farm Ponds
	6	Lakes
	7	Void
	8	Void
	9	Void
	10	Void
	11	Void

Variable 2 (Elevation)		
Subvariable	0	300
	1	310
	2	320
	3	330
	4	340
	5	350
	6	400
	7	450
	8	500
	9	550
	10	Void
	11	Void

Variable 3 Cultural/Transportation		
Subvariable	0	None
	1	Unimproved Road
	2	Light duty road
	3	Medium duty road
	4	Heavy duty road
	5	Structures
	6	Cemeteries
	7	Urban
	8	Archeological
	9	Void
	10	Void
	11	Void

Variable 4 Soils (Div. 1)		
Subvariable	0	Void
	1	JE
	2	JK
	3	LPB
	4	LUC2
	5	LUD2
	6	LUE
	7	MA
	8	OAB2
	9	OAC2
	10	OAD2
	11	PT

Table 2-Continued

Variable 5		Land Cover
Subvariable	0	Forest
	1	Pasture
	2	Mineral
	3	Wetland
	4	Row-crop
	5	Void
	6	Void
	7	Void
	8	Void
	9	Void
	10	Void
	11	Void

Variable 6		Forest Stand Composition
Subvariable	0	Void
	1	Upland hardwood
	2	Upland pine/hardwood
	3	Upland pine
	4	Bottomland hardwood
	5	Bottomland pine hardwood
	6	Bottomland pine
	7	Mixed Oak, Hickory, Sweetgum
	8	Swamp Tupelogum, Cypress
	9	Maple, Ash, Sugarberry
	10	Void
	11	Void

Variable 7		Proximity to 2nd Order Streams
Subvariable	0	In cell
	1	1 cell away
	2	2 cells away
	3	3 cells away
	4	4 cells away
	5	5 cells away
	6	6 cells away
	7	7 cells away
	8	8 cells away
	9	9 cells away
	10	Void
	11	Void

Variable 8		Proximity to 3rd Order Streams
Subvariable	0	In cell
	1	1 cell away
	2	2 cells away
	3	3 cells away
	4	4 cells away
	5	5 cells away
	6	6 cells away
	7	7 cells away
	8	8 cells away
	9	9 cells away
	10	Void
	11	Void

Table 2-Continued

Variable 9	Proximity to Ox-Bow Lakes	
Subvariable	0	In cell
	1	1 cell away
	2	2 cells away
	3	3 cells away
	4	4 cells away
	5	5 cells away
	6	6 cells away
	7	7 cells away
	8	8 cells away
	9	9 cells away
	10	10 Void
	11	11 Void

Variable 10	Proximity to Wetlands, Bottomland hardwood, Mixed oak, Swamp Tupelogum Cypress	
Subvariable	0	In cell
	1	1 cell away
	2	2 cells away
	3	3 cells away
	4	4 cells away
	5	5 cells away
	6	6 cells away
	7	7 cells away
	8	8 cells away
	9	9 cells away
	10	10 cells away
	11	11 Void

Variable 11	Proximity to Row-Crops	
Subvariable	0	In cell
	1	1 cell away
	2	2 cells away
	3	3 cells away
	4	4 cells away
	5	5 cells away
	6	6 cells away
	7	7 cells away
	8	8 cells away
	9	9 cells away
	10	Void
	11	Void

Variable 12	Proximity to Prime Farmland	
Subvariable	0	In cell
	1	1 cell away
	2	2 cells away
	3	3 cells away
	4	4 cells away
	5	5 cells away
	6	6 cells away
	7	7 cells away
	8	8 cells away
	9	9 cells away
	10	Void
	11	Void

Table 2-Continued

Variable 13		Soils (Div. 2)	Variable 14		Proximity to Row Crops in Prime Farmland
Subvariable	0	Void	Subvariable	0	In cell
	1	SBA		1	1 cell away
	2	SBB		2	2 cells away
	3	SDC2		3	3 cells away
	4	SDE		4	4 cells away
	5	SMF		5	5 cells away
	6	STF		6	6 cells away
	7	Void		7	7 cells away
	8	Void		8	8 cells away
	9	Void		9	9 cells away
	10	Void		10	Void
	11	Void		11	Void

Due to the small size of the corridor, approximately 8.6 sq. mi., with 0.52 ac cells, aircraft imagery was utilized for land cover identifications; the system will, however, accept classified Landsat digital data. At the request of the Environmental Division of the Mississippi Highway Department, selection of the variables to be input to the data base was made by a group of University personnel which included zoologists, wildlife ecologists, an agronomist, an engineer, an agricultural engineer, and a forester. This committee later developed and evaluated models designed to indicate the vulnerability of cells in terms of environmental impacts to highway construction. Of particular concern was the impact on wetlands. The final model is presented in Table 3. An example of the model output is illustrated in Figure 5.

Table 3
Suitability Model for Route Impact, Highway 78 Bypass

SUITABILITY INDEX EVALUATION FORM

Suitability Index Name Route Impact

Study Highway 78
Date December 1979

Variable No.	0	1	2	3	4	5	6	7	8	9	10	11	Weight	Weight Percent
Surface Water	9	1	2	5	0	7	0	0	0	0	0	0	10	10.53
Cult./Transp.	9	9	9	9	9	2	2	1	0	0	0	0	10	10.53
Soils - Div. 1	9	2	2	9	8	7	3	3	9	8	7	1	15	15.79
Soils - Div. 2	9	9	9	8	7	4	4	0	0	0	0	0	15	15.79
For. Stand Comp.	9	7	8	8	2	5	7	3	1	4	0	0	15	15.79
Pr. Wetlands	1	2	6	9	9	9	9	9	9	9	0	0	5	5.26
Land Cover	7	9	6	2	8	0	0	0	0	0	0	0	10	10.53
Pr. 2nd Order St.	1	2	9	9	9	9	9	9	9	9	0	0	5	5.26
Elevation	5	5	7	9	9	9	7	7	7	7	0	0	5	5.26
Pr. Oxbows	2	4	9	9	9	9	9	9	9	9	0	0	5	5.26

Rate each value for each variable from 1 (low to 9 (high)

To reject a cell on a particular condition, code a 0 under those particular variable values.

Weight - relative contribution of each variable to attractiveness or vulnerability

Figure 5 . An environmental impact model of a portion of the Highway 78 Bypass area; darker tones indicate low impact, lighter area high impact, and white areas are excluded (lakes, oxbows).

Current Status

Data analysis has been completed, and the data base is being placed in the interactive graphics system. A Status Report prepared by the Environmental Division of the Mississippi Highway Department is included as Appendix VI.

Future Plans

Program personnel will continue to encourage the acceptance of the methodology by the Highway Department. In the event of acceptance, the software package will be modified to a format acceptable by Highway Department computers. Highway Department personnel will also be trained in the use of the methodology.

IV. LIST OF SPECIAL ASSISTANCE OFFERED

Information Supplied or Publications Supplied

Mr. Chris Elmore, Entomological Services, Oxford, MS

Mr. Charlie Craig, Ag-Test, Inc., Friars Point, MS

Mr. Mike Ruffin, International Paper Company, Winnsboro, SC

Dr. J. Riom, Laboratoire de'Ecologie de la Pinede Landaise, Pierroton, France

Ms. Donna Loucks, Weyerhaeuser Company, Centralia, WA

Lowndes County Board of Supervisors, Columbus, MS

Civil Defense Director, Lowndes-Columbus, Columbus, MS

Mississippi Highway Department, Jackson, MS

Mississippi Minerals Resources Institute, Oxford, MS

Dr. Ronald P. Anjard, Maison de Anjard, Kokomo, Indiana

L. Bennett/SF5, NASA-Lyndon B. Johnson Space Center, Houston, TX

Mr. Mark E. Schultz, Albany, California

Miss Carole Girard, Chelmsford, Ontario, Canada, POM ILO

Demonstration and Educational Activities

Demonstrations of the interactive color graphics system and tours of the MSU Remote Sensing Laboratory were given to the following groups:

U. S. Senator John Stennis and party

Mississippi Forestry Association Board of Directors

An advanced remote sensing class in geography

Landscape architecture students

Personnel from the Jackson Office of the U. S. Fish and Wildlife Service

Personnel from the Waterways Experiment Station, U. S. Corps of Engineers

Facilities

No further expansion of facilities has taken place during the last six months. There are, however, negotiations underway with the University to acquire a room approximately 15 ft x 30 ft dedicated to the interactive graphics/image processing system. Provision has been made for a remote sensing laboratory in preliminary plans for a new forestry building to be constructed approximately three years in the future.

APPENDIX I

COMPUTER-ASSISTED DATA BASE MANAGEMENT MODELS FOR HAZARD VULNERABILITY ANALYSIS IN LOWNDES COUNTY, MISSISSIPPI

by
Ray M. Gildea, Director
Columbus-Lowndes Civil Defense Council

Prepared for the
Association of American Geographers Annual Meeting
Louisville, Kentucky
April 14, 1980

ACKNOWLEDGEMENTS

The author is deeply indebted to a number of individuals both in various levels of government and in academia for their respective contributions to this paper. First, I greatly appreciate the interest and enthusiasm for this program shared by the Mayor of the City of Columbus, Mr. James M. Trotter and the President of the Lowndes County Board of Supervisors, Mr. W. G. "Bit" Thompson. Their full and unqualified support enabled me to pursue this project "with both hands". Secondly, I would like to thank Mr. Jim Maher, Director of the Mississippi Civil Defense Council for his visits and correspondence throughout the course of this project. I should also like to acknowledge the assistance of Mr. Jack Bryan, Federal Emergency Management Agency, Region IV, Systems Analyst. His sharing of materials, contacts, and ideas has been instrumental both in researching this paper and in developing the hazard analysis procedures. Next, let me thank Mr. Frank Miller, Remote Sensing Applications Program Coordinator, and his graduate assistants, Ms. Rena Haynes, Mr. Jon Clark, and Mr. John Powers at Mississippi State University for their eagerness to involve local officials in grass roots utilization of the LANDSAT based geo-information system. Last of all, I would like to thank my father, Dr. Ray Y. Gildea, Jr. whose expertise helped to transform an ordinary government project into a geographically-oriented case study in community hazard perception. Each of these people has, in his own way, helped to instill in me high standards of personal excellence and a compelling desire to serve my community by taking full advantage of our existing resources.

Ray M. Gildea, Director
Columbus-Lowndes Civil Defense Council
April, 1980

COMPUTER-ASSISTED DATA BASE MANAGEMENT MODELS FOR
HAZARD VULNERABILITY ANALYSIS IN LOWNDES COUNTY, MISSISSIPPI

At all levels of government a trend is developing toward systematic treatment of hazard mitigation and damage reduction problems. A number of federal programs involving law enforcement, fire protection, and emergency management have encouraged utilization of computer-assisted geobase systems to aid local government in conducting hazard analysis activities. Nearly all of these projects have been carried out in highly urbanized metropolitan places using the U. S. Census Bureau's, Dual Independent Map Encoding (DIME) configuration. Smaller communities may choose other computer-assisted methodologies including Landsat-based information systems. This paper summarizes the experience of a medium-sized predominantly rural county with the adaptation of a cell based, geo-information system for emergency services planning and hazard vulnerability analysis.

Recent federal policy initiatives designed to make hazard mitigation activities a requirement for disaster assistance may further stimulate the application of computerized geobase systems to hazard analysis problems.[1] Reorganization of federal emergency services under the aegis of the Federal Emergency Management Agency (FEMA) has brought about increased emphasis on the methodical evaluation of natural hazard vulnerability factors. A national hazard vulnerability data base is currently under consideration at policy-making levels within FEMA. Research sponsored by the National Governor's

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1 The Federal Disaster Assistance Administration (FDAA) has promulgated proposed regulations for hazard mitigation: 24 CFR Part 2205. These Rules require communities to undertake comprehensive investigations to identify and evaluate hazard vulnerability problems. Provisions also ensure a federal commitment to provide appropriate technical assistance to state and local agencies engaged in damage reduction projects.

Association, has provided a basis for county to county comparison of hazard probability.[2] The establishment of such a base as a repository for information collected by a host of federal and state agencies would further encourage local development of computer applications for emergency preparedness planning. Three basic kinds of information have been identified for inclusion in this project:

1. Risk Data - Any assessment or statistical indicator of hazard probability comparable on a county to county basis.

2. Vulnerability Data - A measure of potential hazard impact on property and lives.

3. Incident Data - An ongoing record of the number of times that a county has experienced a specific hazard impact.

In addition to offering great potential for recognition of common hazard problems, this type of activity at the national level may help to eliminate differences in data collection methods and analytical formats.

Regional projects may also influence local applications of geobase systems for emergency management activities. A proposal establishing a data base for the southeastern United States to monitor disaster occurrences and evaluate disaster potential is being advanced by FEMA, Region IV.[3] Briefly stated, the purpose of the proposed project is to aid states and counties in improving performance with regard to hazard mitigation, emergency response, and disaster recovery efforts. The data base would also assist in identifying capabilities and resources in each county which reflect the current status of local emergency planning programs.

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2 A recent draft report for the National Governor's Association Center for Policy Research: Emergency Management Project entitled: Hazard Mitigation Study: Interim Report Providing Basis for Completion of 80 Case Study, outlines hazard data base sources and rating scales. It also contains matrices showing hazard impact ratings for natural and man-made disasters by county.

3 In his project proposal, "Regional ADP Applications For: Disaster History/ Disaster Potential/Program Status Inventory" FEMA Region IV Computer Analyst, Jack Bryan has addressed some of the format and data collection problems posed by a regional data base.

While the previously mentioned programs are currently underway to footer a county-level approach to hazard vulnerability analysis, several locally initiated projects have been established to build geobase systems which enable urban communities to undertake complex emergency services allocation activities. Typical of these pilot programs is the Fire Alarm Assignment System (FAAS) prepared by the National Fire Protection Association for the United States Fire Administration.[4] FAAS is a DIME based information system currently utilized in at least nine large metropolitan areas. It is designed primarily for real-time use as a computer-enhanced dispatching system. In addition, the system is also used in long range analysis of fire service manpower and resource distribution. DIME's geocoded street file system provides a means to determine travel routes to and from fires, as well as a means to validate the accuracy of response data. This capability can be extremely valuable in metropolitan communities where dispatchers and emergency preparedness planners are not able to route emergency traffic based solely on cognitive mapping skills.[5]

While DIME based systems have proved valuable to law enforcement, fire service, and emergency management agencies in large urban areas, other methodologies may be more appropriate in smaller communities. Although urban space is relatively well defined using a street grid network, one of the most compelling reasons why metropolitan areas have opted for the DIME format is that it has been prepared for 250 Standard Metropolitan Statistical Areas (SMSA's) by the United States Bureau of Census.

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4 Fire Alarm Assignment System, prepared by the National Fire Protection Association for the Federal Emergency Management Agency under grant #APR76-19036, February 1979, includes a user's manual and a systems reference manual, in addition to a final report.

5 In Determining the Travel Characteristics of Emergency Service Vehicles, Jack Hansner and Warren Walker discuss dispatch problems in considerable detail. The New York City Rand Institute, R-1687-HUD, April, 1975.

In contrast to the requirements of large cities, officials in smaller less urbanized places, are less interested in a computer-aided system to route emergency traffic and more concerned with interrelating geographic information in order to deal with burgeoning service requirements. Rural places are not as well delimited in terms of street segments and road grids. The DIME system is not well adapted for use in areas where large spaces are not differentiated by nodal traffic networks. Furthermore, the size of the community often has little bearing on the decision to select a mechanism for storage of disaster information. Cost-effectiveness is more accurately determined by examining a community's average annual damages from recurring natural disasters, rather than strictly in terms of threshold size.

Lowndes County, Mississippi is representative of medium-sized communities where average annual damages from natural disasters exceed one million dollars ($1,000,000). Widespread flooding has been responsible for two presidential disaster declarations during the past seven years, resulting in more than thirty million dollars($30,000,000) in damages to private property alone. Although the county's population, (about 55,000), is dispersed over five hundred square miles, the extensive scope of damages from natural disasters, especially floods, has motivated local officials to cooperate in order to develop an effective program aimed at significant damage reduction and hazard mitigation planning. The Columbus-Lowndes Civil Defense Council is a city/county agency which has been asked to coordinate a systematic approach to hazard vulnerability analysis.

Civil Defense, in conjunction with the Remote Sensing Application Program at Mississippi State University, has adapted a Landsat-based, geo-informational system using grid cells to develop a county-wide disaster planning program. The overall purpose of the project is to evaluate emergency response patterns to suggest possible sites for locating future emergency service facilities and to identify strategies to reduce damages to both public and private property.

Utilization of the Lowndes County data base for hazard vulnerability analysis begins with the delineation of hazard-prone areas. These areas are designated based on suitability models which intercorrelate variables resident in the data base. The suitability modeling process uses the Computer-Assisted Land Use Planning (CALUP) software package developed at Mississippi State University.[6] The package is composed of a series of programs allowing the user to interactively access the data base. It also permits the modeling of interrelationships between data base variables to depict the suitability (or lack of it) of land areas for a particular activity. Attractiveness, as well as vulnerability, can be defined by environmental, aesthetic, and economic parameters.

Taking a flash flood model as an example, the following variables were considered: soil type, slope, proximity to medium and heavy duty roads, proximity to first, second, and third order streams, as well as Landsat computer compatible digital data. Slope data was obtained from National Cartographic Information Center (NCIC) digital terrain tapes. During the construction phase of data base development, primary variables were digitized from geographic information provided by state and local authorities.[7] This information describes physical, cultural, and biological characteristics on a county-wide basis.

Output from the models showing the relative suitability of each cell is

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6 A description of the CALUP development and data base construction appears in an article entitled: "Rational Land Use Decision-Making: The Natchez State Park" in Remote Sensing and the Environment 8:25-38 (1979).

7 Details are recorded in: Semi-Annual Progress Report, No. 9-11, NASA, Grant NGL-25-001-054.

available in one of three forms: hard-copy maps, produced by the system's line printer, color displays on the raster graphics screen of the minicomputer's image processing system, or hard-copy printouts on the electrostatic printer/plotter. The image processing system hardware, consisting of a Lexidata 6400 image processor and a Nova 3 micro-computer, is connected as a peripheral to a host Data General Eclipse S130 micro-computer with 256K bytes main memory. Also peripheral to the minicomputer are: a 96 megabyte disc, a 9-track 800 b.p.i. tape drive, a Varian Statos 4222 electrostatic printer/plotter, and a Conrac graphics display terminal. The minicomputer is interconnected to a Univac 1100/80 main frame computer system which is remotely located. Software programming is written in FORTRAN. Communication takes place between the image processing system and the minicomputer when library programs are down loaded into the image processor from the Lexidata program library. The system's hardware is designed for raster image processing only. This is the primary reason for the cell based orientation of the image processing system.

Base data is digitized from maps and stored in five acre cells, the smallest land unit currently defined by Lowndes County geobase parameters. Secondary variables relate proximity data, that is, distance, in number of cells, from particular conditions described by specific variable combinations. The following are examples of primary variables: "Slope", "Soil Association", and "Utility Rights-of-Way". Each primary variable is divided into subcategories. Each cell is described by exactly one subvariable category for each variable. The subvariables of the "Utility Rights-of-Way" variable are "Gas or Oil Pipelines", "REA Lines", "TVA Transmission Lines", and "None". Every cell in the Lowndes County data base can be described in terms of this variable by one of the above categories. The same is true, of course, for each of the other variables. An illustration of a secondary or proximity variable might be, for example, "Proximity to Public Facilities or Industrial Land Use", Subvariables of this secondary variable range from: "Land use in cell" to "Land use nine or more cells away".

Five distinctly different project application types are currently being carried out in connection with this program. In the first type, computer models define county areas through the designation of relative hazard vulnerability ratings. Rating models are under development for these risk types: high frequency flooding, flash flooding, historical flood events, power outages, transportation accidents, and fires. Taking flash flooding again as an example, local officials are working with hydrologists from the Southeast River Forecast Center (SERFC) in Atlanta, Georgia to show the spatial impact of various flash flood scenarios on local streams, as well as the existing urban drainage system. The SERFC is developing flash flood models for two Lowndes County creeks based on flood risk evidence generated by the system.[8] However, these models only show vertical stage heights. The forecast information generated by SERFC models is translated using project data to show where flooding will occur. Transforming stage data into a county-wide spatial framework helps local officials to visualize the possible problems posed by a specific flood event. The hazard vulnerability model for flash flooding has been utilized to evaluate areas which were not studied in detail by the Federal Insurance Administration (FIA) in its flood insurance study. Officials are also working with FIA engineers to alter current maps to reflect this information.

A second type of computerized data base application related to disaster planning creates disaster/response models to analyze community response capabilities with regard to each of the previously mentioned hazard vulnerability types. In order to develop these models, officials are integrating geographic data from the Lowndes County data base with information stored in

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8 Comprehensive treatment of flood modeling techniques and application for Lowndes County appears in: "Semi-Annual Report No. 12, to the NASA, Technology Transfer Division by the Remote Sensing Application Program at Mississippi State University.

the Civil Defense micro-computer located in the Lowndes County Emergency Operating Center. Officials are evaluating relationships between the following factors: specialized training required and available, specialized equipment required and available, warning systems, public information systems, hazard prevention programs such as land use, building regulations, and historical data regarding past occurrences.

A number of disaster planning activities have been carried out through the use of the Landsat-based data management system. Real-time utilization of a hazard-response model occurred during the Summer and early Fall of 1979 when hurricanes caused extensive local flooding. The first step was to generate models showing probable flood impact areas. Next, the locations of these areas were entered in the Civil Defense micro-computer system to determine who should be notified for possible evacuation, location of possible traffic control points, the names of local officials and volunteers living in or near these areas, the location of critical facilities, and other resources requiring relocation. While these techniques are in need of certain refinements, they do represent an important step forward in local response planning. A similar effort was undertaken during a major flood which took place in April, 1979. The flood severed all east-west arterials causing the virtual isolation of fifteen thousand local residents from essential services for a period of several days. By knowing the location of key personnel and the whereabouts of emergency equipment, local officials can better equip themselves to equitably distribute emergency resources. Similar techniques can be used for demonstration purposes to justify expenditures for better monitoring equipment, procedures, and warning systems.

A third type of hazard vulnerability analysis activity being carried out in Lowndes County utilizes the interactive graphics capabilities of the minicomputer for simulation modeling to plan for crisis evacuation, large scale relocation, and its impact on essential services and resources. Visual display on the system's graphics terminal or hard-copy output provides local officials with a "bird's eye view" of aerial response effects on the community as a whole. Software capabilities encourage modification of parameters, allowing real-time feedback and analysis of emergency decisions and actions. The modeling also provides test scenarios, making public officials aware of the spatial impact of their decisions, given realistic emergency conditions.

A fourth hazard-related application for the Lowndes County land use data base has been developed in cooperation with researchers at the University of Wisconsin.[9] The purpose of this project is to forecast flood damage estimates in relation to the amount of warning time provided to local residents. Stage-damage curves have been constructed for a number of business, industrial, and residential types located in flood plain areas of the City of Columbus in Lowndes County. This data is based on actual field determinations of property damage at various elevations within these structures. This information is combined with aerial data derived from theoretical flood events generated by the geobase information system. Use of the system has brought about several projects including analysis of the cost-effectiveness of the federal flood insurance program in reducing flood damages for various frequency flood events. By utilizing the computer-assisted data base, a number of assumptions can be tested concerning damage reduction as a function of available warning time and the willingness of the general public to take effective preparedness actions.

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9 The stage-damage curves for City of Columbus structures are contained in: Final Report On River Forecast Benefit Evaluation by Harold J. Day and Kwang K. Lee for the National Oceanographic and Atmospheric Administration, National Weather Service, Hydrologic Research Laboratory, 1979.

While the previous four emergency management applications are nonstructural mitigation activities, the fifth computer-assisted project area involves structural decision-making. The decision to locate a new emergency service facility in a particular location must be based, as much as possible, on objective criteria. The Lowndes County geobase system can provide a vehicle for facilitating the selection of an appropriate site. A recent example illustrates the process of emergency resource allocation planning in locational decisions at the grass roots level.

The Lowndes County fire department program is a voluntary effort established in 1976, to provide county-wide fire protection. Since that time, five volunteer fire departments have been established, one in each of the county's five supervisor's districts.[10] During the past four years, this rapidly expanding program has been responsible for the purchase of five 750 gallon pumpers and the erection of five fire stations.

With five permanent departments developing in Lowndes County, an advisory group, the Lowndes County Fire Protection Association, has begun the preparation of long range plans and the evaluation of fire response performances. After lengthy discussion, the Association proposed the construction of substations for existing departments to be located in areas with the highest fire risk and the weakest overall fire response performance record. The individual departments did not agree on the priorities for substation construction. A systematic approach to analysis of fire response records was needed to bring a measure of objectivity to the fire facility planning process.

As County Fire Coordinator, the Lowndes County Civil Defense director

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10 A booklet entitled: Firewatch: Lowndes County Fire Protection Through Volunteer Service, Southern Printing Company, 1978, describes the growth and development of this program.

decided to use the Lowndes geobase information system as a means of pinpointing suitable locations for fire stations and setting priorities for prospective sites. Department records for the entire history of county fire response (1977-79) were analyzed in detail. Information concerning each fire was inputted into the data base for use in the project. The new variables and respective subvariables are as follows:

FIRES IN LOWNDES COUNTY BY TYPE

No Fire
Auto Fire
Transport, Truck Fire
Grass Fire
Forest Fire
Agricultural Building Fire
Residential Fires Greater Than $20,000
Residential Fires Less Than $20,000
Mobile Home Fire
Commercial/Industrial Fire
Railroad Fire
Public Buildings and Church Fire
Other Fire

STRUCTURAL FIRE DAMAGE

No Fire
No Structural Damage
Less Than or Equal to 10% Damage
Less Than or Equal to 20% Damage
Less Than or Equal to 30% Damage
Less Than or Equal to 40% Damage
Less Than or Equal to 50% Damage
Less Than or Equal to 60% Damage
Less Than or Equal to 70% Damage
Less Than or Equal to 80% Damage
Less Than or Equal to 90% Damage
Total Loss Greater Than 90% Damage

PROXIMITY ZONES TO FIRE STATIONS

Fire Station in Cell
Fire Station 1-5 Cells Away
Fire Station 6-10 Cells Away
Fire Station 11-15 Cells Away
Fire Station 16-20 Cells Away
Fire Station 21-25 Cells Away
Fire Station 26-30 Cells Away
Fire Station 31-35 Cells Away
Fire Station 36-40 Cells Away
Fire Station Greater Than 40 Cells Away

After studying the data thoroughly, the firemen decided that structural damages in excess of fifty percent of the value of the building and its contents occurred on the average three to three-and-a-half miles from the location of the fire station. Variations in response performance within this perimeter have been attributed to several factors. The most significant of these factors appears to be the time of day at which the fire occurs. Excessive fire losses within the defined serviceable areas tend to occur during daytime hours when volunteers in rural communities are unavailable. Improvement of response time to these fires might involve a non-structural solution. For example, several departments are considering the training of housewives as daytime firefighters.

Interpretation of fire data is highly problemmatical for several reasons. An attempt has been made to exclude arson and other incendiary fires from analysis. The entire vehicular fire category is being ignored because of the extremely high percentage of arson-related incidents. The firemen were most interested in fire damages to structures in the following categories: residential fires greater than $20,000, agricultural buildings, commercial and industrial fires. In all but two cases, mobile home damages exceeded the fifty percent breakpoint criteria. Therefore, mobile homes were considered separately from the above categories in fire response planning models.

By plotting the locations of structural fires with a high percentage of damage, the Lowndes County Fire Protection Association is able to identify problem areas where additional facilities are needed. The firemen basically want to know the location of serviceable and non-serviceable areas given current status manpower and equipment deployment patterns from the standpoint of realistic fire protection standards. The firemen themselves were asked to provide the required definitions to assess the adequacy of response. The firemen beleive that in the case of most structural fires excessive damage occurs no more than ten minutes following the reporting of a fire. Using this perception as a general "rule of thumb", service areas for fire departments were modeled using several different breakpoints. Breakpoints were based on various threshold values for percentage of damage in structural fire categories. While the breakpoint for fifty percent damage is three to three-and-a-half miles, the breakpoint for ninety percent damage is six to seven miles, depending upon the district.

In addition to using the new fire performance variables, models were created to identify prime growth areas where possible future demands for fire service may develop. Existing fire potential models were also determined by combining the following factors: the location of high and low density residential development, the location of major arterials, rail lines and crossings, the location of airports and major industries. This information was weighted and integrated with fire occurrence data to set priorities for the locations of future fire substations. After manipulating service area boundaries based on past performance, future growth areas, the location of existing development, and transportation routes, departments were able to determine where service was satisfactory and where additional facilities might be needed.

As a result, three sites have been identified for substations. Members of the Board of Supervisors have indicated that construction might begin next year on the first of these sites. Hard-copy output depicting the fire variables was exhibited at Lowndes County Firemen's Appreciation Day ceremonies held in February, 1980. The cell based geo-information system advanced by Lowndes County officials for hazard vulnerability analysis provides a viable alternative to polygonal systems like the DIME geobase. Each of these two approaches has its advantages and disadvantages.

With the polygonal approach, as in the DIME configuration, the data base is stored as raw coordinates of subvariable features within mutually independent variable classes. The data base is, in a sense, generated every time it is queried. The coordinates of features within stored variable classes are generated as required. Only those variable classes which are referenced are generated. Therefore, mass storage requirements for data are reduced compared to the grid system. Another advantage lies in the capability of the system to be adjusted from one scale to another. Disadvantages lie primarily in the extremely abstract representation of the data base to noncomputer-oriented users. Software in such a system must do a considerable amount of "bookkeeping" among different variable classes during modeling. The capacity to alter the scale of the data base at will is paid for by increased computing overhead and potentially slower response. For data bases involving intricate and complex networks, such as urban areas, the polygonal approach is clearly superior.

In a system input of digitized remote sensor data. the fixed grid approach is more desirable. The image data already exists in grid form. Therefore, data input is merely a matter of geo-referencing points common to the data base as well as the image by using existing programs to register the grids. In the polygonal method, the digital grid image must be converted to polygonal coordinates. This is a major programming task requiring independent specialized software, extensive transformation, or manual input of coordinates. Again, it is apparent that polygonal systems, like the DIME, are urban-oriented, while cell based systems using digital imagery tend to be rural or regionally-oriented. County imagery is best attained by satellite; urban applications are more likely to utilize low altitude, non-digital imagery and tend to be inputted manually.

Both systems possess sophisticated modeling ability. The advantage of a fixed cell system, like the data base used for Lowndes County hazard analysis, lies in its requirement for less computer memory for program storage, enabling it to run on a smaller, less expensive system. Both systems lend themselves well to display of information on a color CRT monitor. The fixed cell system lends itself to a line printer whereas a DIME type system would tend to favor plotter output for models.

Both DIME based polygonal systems and cell based systems are needed for construction of automated image processing systems for hazard vulnerability analysis. In urban areas the DIME system works well and is already in extensive use. Rural areas have been previously overlooked as far as the construction of locational data bases for emergency management is concerned. However, cost-effectiveness regarding data base development must be considered not only in terms of threshold size, but also in terms of average annual damages or some other economic measure of the impact of recurring natural disaster hazards on a particular community.

Lowndes County officials turned down an offer from the Defense Civil Preparedness Agency a couple of years ago to participate in a DIME based emergency management data processing pilot program. Instead, authorities elected to pursue hazard planning applications on a cell based system located at Mississippi State University. During the last several years the Columbus-Lowndes Civil Defense Council has coordinated the development of a wide range of projects designed to take full advantage of the capabilities of this system to handle emergency management tasks. The Lowndes County experience may serve as an example of the use of a grid based system to develop a framework for a county-wide approach to hazard vulnerability analysis in medium-sized communities.

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APPENDIX II

USERS' GUIDE

FOR

DECISION TREE CLASSIFIER

Nancy Freeman

Dept. of Mathematics

325-4404

The purpose of this memo is to enable a person unfamiliar with the computer system at Mississippi State University to make the computer runs necessary for generating output from the DECISION TREE CLASSIFIER.

A standard Larsys format data tape will be input to the program to be run, RATIO. RATIO generates an output tape which will be the input tape for the next two programs. All tapes used should already be labeled with a number consisting of 3 letters and 3 numerals, for example, LRS009 or RSP004. There should also be a label on the tape telling what data is in each file. After a user's program outputs to a tape, the user should affix a label to the tape case and note the file number written to and the nature of the data. In the following example, LRS009 is the Larsys data tape used for input data with the data in the first file; LRS011 is the output tape, data will be written to file 3.

```
@RUN   FRATIO,ENP005F,CARTER,10,100
@ASG,A   JSC.
@ASG,THJ   11,16N,LRS009
@MSG,W   PLEASE MOUNT LRS009 RING OUT.
@ASG,THJ   12,16N,LRS011
@MSG,W   PLEASE MOUNT LRS011 RING IN.
@XQT   JSC.RATIO
    1    3
  154   50
```

pink card - available at computer center

Notes on input cards:

FIRST CARD: FRATIO is a 6-letter identification for the computer run. The user may use any 6 letters of his choosing. Computer runs are filed in the pick-up bins by this ID. ENP005F is the charge number currently in use for runs on this contract; if it changes, users should be notified. The remainder of the card should be left as is.

THIRD and FIFTH CARDS: 16N refers to a nine-track tape which is what most tapes on the current system are. If the user has a seven-track tape, 16N must be changed to 16. It is very important that the input tape number be on the card with the 11 and that the output tape number be on the card with the 12.

EIGHTH and NINTH CARDS: The last digit of the first number should be in column 5 and the last digit of the second number should be in column 10, (2I5 format). None of the four numbers can be more than 5 digits. The first number on the eighth card is the number of the file being used on the input tape; the second number is the file being used on the output tape. The first number on the ninth card is the starting line for the input; the second number is the number of lines to be read.

After the RATIO run has been completed, the user is ready to make the ISOCLS run. The data output by RATIO is used as input to ISOCLS. ISOCLS is used to generate the statistics cards for the next program.

```
@RUN    ISORUN,ENP005F,CARTER,10,1000/5000
@ASG,THJ    3,16N,LRS011
@MSG,W    PLEASE MOUNT LRS011 RING OUT.
@ASG,A    JSC.
@XQT    JSC.LARSAA
$ISOCLS
OPTION    STATS
OPTION    PUNCH=1
CHANNELS  DATA=1,2,3,4,5,6,7,8,9
DATAFILE  FILE=3
STDMAX    3.0
DLMIN     2.8
*END*
CLASSNAME ALL
TEST      (1,1),(520,200),(640,200),(640,320),(520,320)
$END*
$EXIT
pink card
```

Notice that LRS011 is the tape from RATIO. Since we wrote to the third file, the DATAFILE card has FILE=3. The data following the key words (OPTION, CHANNELS, etc.) must begin in column 11. The TEST card gives the vertices of the area being worked with in this order: upper left, upper right, lower right, lower left. The PUNCH option causes card output to be generated in addition to the regular printout. Cards are usually ready a day or two after the printout. WARNING: There are sometimes errors in cards punched by the system. These cards will come back with no printing across the top. If you would like a printout of what is on your cards before you make the CLASSIFY runs, you can make the following run:

```
@RUN   XPRINT,ENP005F,CARTER
@ELT,LID   MODULE
   (your cards)
   (pink card)
```

The examples in this memo for CLASSIFY and DTCLS correspond to the decision tree presented on the last page. A CLASSIFY run must be made for each level of the decision tree.

First run:

```
@RUN   XCLASS,ENP005F,CARTER,10,300
@ASG,CP   TF1.
@USE   2,TF1
@FORMS
PLEASE TURN PAPER OVER.
@ASG,A   JSC.
@MSG,W   PLEASE MOUNT LRS011 RING OUT
@ASG,THJ   3,16N,LRS011
@ELT,LID   MODULE
     stat cards
@END
@XQT   JSC.LARSAA
$CLASSIFY
OPTION     STATS
DATAFILE   UNIT=3,FILE=3
APRIOR     3*.02,.016,5*.03,.2,.15,.2,.15,2*.024,.01,.016
CHANNELS   DATA=4,9,STAT=4,9
```

```
@ADD   MODULE
*END*
TEST1     (1,1),(520,200),(640,200),(640,320),(520,320)
$END*
$EXIT
     (pink card)
```

Only three cards must be changed to make the second and third runs - the @ASG,CP card, the @USE card and the CHANNELS card. These cards should be as follows:

```
Second run - @ASG,CP   TF2.
             @USE   2,TF2
               .
               .
               .
             CHANNELS  DATA=6,9,STAT=6,9
Third run -  @ASG,CP   TF3.
             @USE   2,TF3
               .
               .
               .
             CHANNELS  DATA=1,3,STAT=1,3
```

The files TF1, TF2 and TF3 are used as input to the decision tree classifier. It is very important to remember which file corresponds to which run since the runs are matched to the levels of the decision tree.

The run stream for the decision tree in the example is:

```
@RUN   DTREEC,ENP005F,CARTER,5,100
@ASG,T   19.
@ASG,T   20.
@ASG,T   21.
@ASG,T   22.
```

```
@ASG,A   TF1.
@ASG,A   TF2.
@ASG,A   TF3.
@USE   20,TF1
@USE   21,TF2
@USE   22,TF3
@FORMS
PLEASE TURN PAPER OVER
@ASG,A JSC.
@XQT   JSC.DTCLS
LEVELS    3
NODE      1 1
BRANCH    2 1 2 3
BRANCH    3 4
BRANCH    4 5 6 7 8 91011121314151617
NODE  W   2 0
NODE  S   3 0
NODE      4 2
BRANCH    5 5 6 7 8 9
BRANCH    610111213
BRANCH    714151617
NODE  C   5 0
NODE  T   6 0
NODE      7 3
BRANCH    81415
BRANCH    916
BRANCH   1017
```

NODE A 8 0

NODE P 9 0

NODE N 10 0

END

(pink card)

The decision tree classifier program can handle up to 10 levels. If there were a fourth level, for example, the user could put the CLASSIFY output into file TF4; assign temporary file 23 and use 23 for TF4 in the DTCLS run. Units 24 - 29 are available for levels 5 through 10, respectively.

NOTES ON INPUT:

All input cards begin in column 1.

NODE cards: the node number (small number by circle on decision tree) goes in columns 9 & 10 in I2 format; if a single digit, put in column 10. If there are branches (arrows) from the node, its level number will go in columns 11 and 12 in I2 format. If it is a terminal node, put 0 in column 12 and the desired display symbol (letter or symbol inside circle) in column 7.

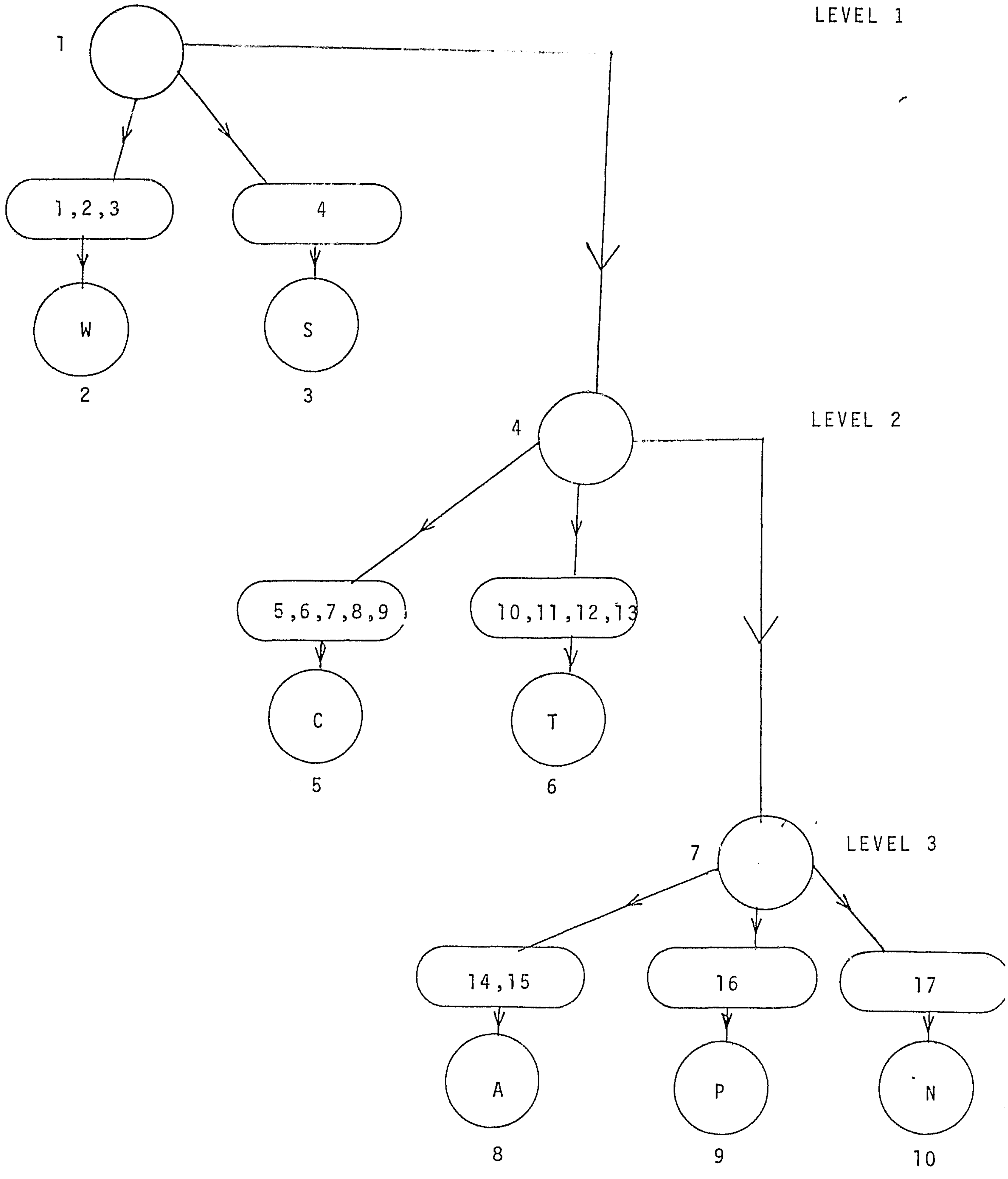
BRANCH cards: Each nonterminal NODE card is followed by BRANCH cards corresponding to the arrows leading from the node. The first number after BRANCH denotes the number of the node to which the arrow leads and is in columns 9 and 10 in I2 format. Beginning with column 11 and using I2 format are the classes which take that branch. For example, there are 17 classes at level 1 for the decision tree presented with the first 3 classes branching to NODE 2, the fourth to NODE 3 and the remainder to NODE 4 as indicated by the BRANCH cards following the NODE card for NODE number 1 in the sample run stream.

If the user desires a copy of the decision tree classifier program, he may submit the following cards:

```
@RUN    PRINTX,ENP005F,CARTER
@ASG,A    JSC.
@PRT,S    JSC.DTCLS
     pink card
```

DECISION TREE

with 3 LEVELS



APPENDIX III

Digital Data Bases in White-Tailed Deer Management: A Pilot Program at the Tallahala Wildlife Management Area, Mississippi

Jonathan R. Clark

David C. Guynn, Jr.

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Presented at the Third Annual Meeting of the Southeast Deer Study Group, 11-13 February 1980, at Stephen F. Austin State University, Nacodoches, TX.

Many types of information are necessary in the effective management of the white-tailed deer. State and local management policies, the political climate of the day, the desires of certain publics, the status of the target deer population, and information on habitat quality are all recognized as necessary inputs to a management plan.

In order to satisfy its needs for habitat data, the Mississippi Department of Natural Resources has undertaken to develop a State-wide habitat data base oriented towards white-tailed deer management. This data base will be a management oriented planning tool which will provide a mapped display of white-tailed deer habitat in the State. This data base scheme will also provide for the evaluation of habitats.

We have chosen to view deer habitat as a series of separate variables which act together to form a composite of a habitat. Keeping the variables separate initially permits efficient collection of data in the field. Viewing them together approximates real ecosystems.

This approach is realized in a geographically referenced, computerized habitat data base. Information is collected from a variety of sources and stored as digital maps in a computer. This information is then used to produce maps of the habitat itself or of areas conferring to specified habitat quality criteria.

Four game management areas in Mississippi have been selected for demonstrating this approach. Each study area is from 40,000 to 60,000 acres in size and represents a different physiographic region of the State. These physiographic regions have been shown to have different soils and vegetation associations and different levels of habitat productivity for deer. The utility of this data base method under differing terrain and wildlife productivity conditions will then be demonstrated.

The first task of this effort was to select those variables which would be measured and configured in the data bases. The variables obviously must have biological and management significance for white-tailed deer. The variables have to be geographically referenced to facilitate their storage in the computer. The prime user of these data bases is the State Department of Natural Resources; as such, the variables had to be those which would have State-wide availability. The economy of collection was also a prime requisite; we could not justify the use of a variable whose basic collection would cost a large portion of deer management finances and perhaps take years of field work to complete. Finally, the variable should have reasonable temporal stability, i.e., it should not require a complete update more frequently than every five years or so.

Based on these criteria, the following types of variables were selected:

Political Boundaries

Transportation Networks

Utility Rights-Of-Way

Surface Water Features

Soils Associations

Topography

Land Cover

For Land Cover and Soils, the particular classes of each variable which were collected were and are a source of debate. Land Cover, especially Forests, was classified largely on the basis of physiognomy and density. Soils Groups or "Associations" were determined by grouping of productivity values for forest lands. Considerations were slope, texture, drainage, topographic position, and site index.

The next major step was the actual collection of habitat variables. Choices of particular sources of information were based upon economy and ease of aquisition as well as the timeliness of the data.

Political Boundaries and Surface Water Features were obtained directly from USGS-Topographic Maps. Transportation and Utility corridors were obtained from USGS maps supplemented with air photos and field observations. Soil Associations were mapped using both USDA-Soil Conservation Service county surveys and field observations.

The topography of Mississippi is available in a computer tape form from the USGS-NCIC. These are simply digital versions of the topographic contours shown on a USGS quad sheet. Digitized at points 60 m. apart (ground relevant), these data are used to construct a digital model of the surface of the study area which is fed directly into the data base where it can be combined with any other variables in the system.

An up-to-date source of land cover data for the entire state is not presently available. Ground-based surveys would be extremely expensive. Land cover mapping using aerial photography would be most accurate but the cost of the photography alone would run many tens of thousands of dollars. This approach would additionally require many man-hours of air-photo interpretation work and cartography. Then all the data would have to be converted to computer format.

A relatively inexpensive source of land cover information is the NASA-Landsat system. One of two operational satellites in the Landsat program scans Mississippi once every nine days. So long as atmospheric conditions permit, we have an overflight each nine days from which land cover maps can be produced. Due to this up-to-date character of the Landsat system, it is being used to map land cover.

The nature of the data generated by the satellite requires that a good deal of data processing be conducted to produce a map. Fortunately, NASA completes a majority of this before the user purchases the data.

The satellite scans the earth with a 4 channel optical scanner which measures radiance values in 1.1 acre pixels simultaneously in four spectral bands. These radiance values are telemetered to earth where they are stored as a 4-band data set on computer tape. These tapes can be used to construct various types of imagery suitable for manual viewing. The imagery conforms to National Map Accuracy Standards.

We have used several computer-aided techniques to analyze the digital data tapes and produce land cover maps. Each algorithm or technique has its own sensitivity and accuracy. Mapping of land cover is a major and on-going effort at MSU. The beauty of using the Landsat system for land cover data is that an updated or corrected cover map can be installed in the data base in a matter of seconds; lengthy manual mapping techniques are not required.

Field Work

Field procedures were employed to collect certain types of information available through no other means, as well as to verify and correct much of the other variables entered into the data base.

The status of transportation networks, residences, industrial, and agricultural lands was assessed by road checks. Topography was presumed to be true according to USGS sources. Soils mapping units were extracted from USDA-SCS county surveys and verified/corrected by field checks.

Field efforts to characterize land cover emphasized forest vegetation. This was done because agricultural open lands tend to change between improved pasture, unimproved pasture, and row crops more rapidly than major updates to the data base are planned. Secondly and more importantly, it was felt that so far as deer ecology is concerned, the differences between forest cover types are more significant than the differences between the various types of agricultural lands.

Building the Data Base

Once data have been collected, it is first converted to map format (except Landsat and NCIC data). This is accomplished by plotting data on overlays for a common base map.

The data are then converted to computer data files by the use of the digitizer. The digitizing process converts positions on a map (in this case our base map) to X, Y coordinates and assigns a variable name or value to that coordinate. This entity is then stored in the computer file. After all points on a single overlay have been digitized, the "file" is closed and a new file begun for the next overlay. Each file represents one overlay, which represents one type of variable; e.g., soils, road systems, surface water, etc. The NCIC topographic data and the Landsat-derived land cover data are already in computer file format and are fed directly into the data base file system. The final data base is simply a computerized version of each of numerous map overlays stored in separate computer files.

New information which might be under consideration need only conform to those criteria listed before; i.e., the addition of information to the data base is a routine operation identical to that for the initial overlays and requires no special treatment and will not affect existing data files. Likewise, corrections or updates of portions of existing files are possible through the use of efficient editor routines.

Using the Data Base

The actual evaluation of deer habitat is accomplished through the use of an extremely flexible computer program which examines each cell of the data base. The program uses a logical argument constructed by the user to evaluate the data base on a cell-by-cell basis. The argument is a Boolean statement of the general form.

if Ax_1 and Bx_2 and Cx_3..., then Y

were

x_i is a data base variable

A, B, C, etc., are weighting coefficients, and

Y is a cell which satisfies the argument conditions.

Each cell of the data base is reviewed and its ability to satisfy the argument is determined. This evaluation can involve some or all of the data base variables. Cells which satisfy the argument are "flagged" and printed in a map at the end of the program run.

These data bases, then, become a managerial and planning tool which permits the display and evaluation of white-tailed deer habitat in a given geographic area.

Any existing habitat evaluation procedure can use the data base as basic input data and the results of that procedure displayed. This can facilitate the evaluation of habitat evaluation methods themselves.

By adjusting only one variable at a time while comparing the habitat with herd conditions, the data bases can indicate the significance of a variable in a habitat.

The updating and correction of the data base is, by virtue of being computerized, rapid and economic. Further, new variables can be added or old ones can be deleted without affecting the balance of the data base.

Finally, it should be recognized that while these data bases were originally intended for use in white-tail deer management, they can be used for a wide variety of species. The data is stored largely unbiased and unweighted and can be evaluated by the model for ecological considerations limited only by the knowledge of the user constructing the models.

APPENDIX IV

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I D B M

IMAGE DATA BASED MANIPULATOR

USER MANUAL

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Mississippi State University

4/16/1980

IDBM USER MANUAL

1. Introduction

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IDBM (named for Image Data Based Manipulator) is a geographic information system (GIS) designed to demonstrate and evaluate the powers of the general manipulative functions. A geographic information system may be thought of as a geographically oriented, image based database management system with the addition of some form of image information analysis tool. The images contain location-specific data which is information that is concerned with, or that can be distributed over, land areas.

Many different types of data are location-specific. Property ownership, land use, cover, and elevation contours are all examples of location-specific data. For each type of data there are different types of users performing their analysis. This makes it very difficult for a single generalized geographic information system to support the varied application specific analysis need of its user community. For this reason IDBM was designed to have very strong general image manipulative functions to support, and perhaps even supplant, the individualized analysis tools. By having a single set of image operators that may perform the actions of the bulk of the analysis programs, generality is increased and the current users are still supported. The main advantage of this method is that new users may use the system without having to have an analysis program written especially for them or having to restrict their analysis to existing tools.

There are two types of manipulative functions in IDBM: the simple single image functions and the more complex multi-image combinational functions. The simple manipulative functions work on just the displayed image. The simple manipulative functions in IDBM are color changing, zooming, shifting, and windowing. The more complex functions are based upon image extensions to the eight common arithmetic and logical operators +,-,*,/,&,|,<, and >. They perform their indicated action on two or more images to form a single, resultant image. A detailed explanation of the action of each operator may be found in the documentation of the DRAW command.

The IDBM system is designed to operate on a Data General Eclipse S/130 minicomputer system. A Lexidata color raster graphics system serves as the main graphical image display device. It displays 480 lines of 640 pixels/line in 64 colors. A Varian electrostatic printer/plotter serves as the image hardcopy device. Also included as a part of the system are a card reader, paper tape punch/reader, a magnetic tape drive, and a 90M disc drive. The usual method of data entry to the system is through magnetic tape.

IDBM was written in a modular form and consists of 45 routines and over 2500 lines of code. All but two of the routines were written in Data General FORTRAN V. The other two were written in assembly language. They were, however, originally writter in FORTRAN but the execution speed advantages of assembler necessitated the conversion. Portability of the system has not been diminished as these routines are very simple and conversion to other machines would be very easy. Portability is also not diminished by the use of two Data General supplied run-time routines to create and delete files as these are common to most systems. Portability is influenced by the fact that Data General FORTRAN is recursive and two routines make use of this. The two routines use recursion to parse and evaluate image expressions involving parentheses. The expressions are parsed via an Augmented Transition Network (ATN) to be able to detect errors and give informative error messages. If the system is transferred to another machine without recursive FORTRAN, these two routines must be rewritten. Conversion of the other routines should pose no serious problems.

2. Description of Commands

Most commands to IDBM have several forms. In the following description, arguments enclosed in { } are optional so that any, or none, of the arguments may be included in the command. If the arguments are enclosed in a [ ], one must be specified. Parentheses are used to signify that the arguments go together but they do not actually appear in the command. The uppercase words in the command should be entered exactly as shown. The lowercase words stand for a variable input by the user. In most cases, by just specifying the keyword, any additional information needed by the system will cause prompts to be issued to the user to obtain the information. An answer of 'NO' to any prompt will cause the command to be aborted with no harmful effects. If a mistake is made while typing in a command, the DEL (backspace) key may be used to correct the error. Optionally, the entire command line may be discarded by pressing the \ key.

DEFINE IMGFn {TO ==, AS, =} filename

The DEFINE command is used to set up a relationship between a previously saved image and a temporary image name that may be used in an algebraic and logical expression. Up to nine temporary images, IMGF1 - IMGF9, may be used simultaneously. IMGF0 is the image currently being displayed and can also be used in an expression.

DRAW [filename, expression, HISTOGRAM, (LARSYS (TAPE) n)]

The DRAW command is used to display a particular image, a logical and algebraic combination of images, a bar-chart histogram of the color densities of the image currently being displayed, or a LARSYS formatted tape. When an expression is used, it is evaluated strictly left to right, but parentheses may be used to give precedence. Legal operands in the expressions are IMGF0 thru IMGF9 and integers. Legal operators are +,-,*,/,&,|,<,=, and >. The four arithmetic operators +,-,*,/ perform their respective actions on equivalent pixels in each source image to form the resultant image. For the < and > operators the pixels that do not hold true in the relation are set to zero in the resulting image; those that do are will have a pixel intensity of the first image. The AND (&) operator is defined similarily, where the images are different the result is zero, otherwise they are not changed. Equal (=) has been included for semantic reasons but the action performed is equivalent to the AND operator. The OR (|) operator functions essentially as an overlay where the result of OR'ing two images is the pixel values of the second image where it has information (non-zero) and the first image elsewhere. In short, non-zero values in the second image have precedence and overlay those of the first image.

RELEASE IMGFn

RELEASE is used to remove the relationship between a temporary image name and an image that was created by DEFINE. An image may be redefined without previously being RELEASEd. Releasing IMGF0 clears the screen. The STOP command releases all definitions.

SAVE {in, as} filename description

The SAVE command saves a permament copy of the currrent display on disk under the specified filename. The description may be any message under 80 characters in length that describes the image. A SAVE into IMGF1 - IMGF9 also performs a DEFINE.

COPY filename [TO, FROM] {TAPE} n

The COPY command copies the specified file to or from tape file n and the disk. The first file on the tape is numbered zero (0). If a copy to tape is to be performed, the tape must have a write ring placed inside it.

PLOT [ALL, (LINE(=)frstln, lastln PIXEL(=)frstpx, lastpx)]

PLOT sends a copy of the current display to the electrostatic printer/plotter. Either all or part of the display may be plotted. The plot is a grayscale of the displayed image. Low numbered colors appear black and the higher numbered ones are lighter. The maximum line must be less than 480 and the maximum pixel must be less than 640.

CHANGE n TO [m, (r, g, b)]

This command either changes all pixels in the current display that have color n to color m, or changes color n to have the specified red, green, and blue intensities. The range of n and m is 0 to 63. The range of r, g, and b is 0 to 255.

ENHANCE

ENHANCE applies a linear stretch on the intensities of the pixels to force the data values over the entire displayable range of the system. The change for each pixel p is (p-min)/(max-min+1)*64.

SHIFT [UP, DOWN, RIGHT, LEFT] n

SHIFT moves the entire displayed image n pixels in the indicated direction. Pixels shifted out of the image are permanently lost. Zero valued pixels are introduced on the opposite side.

WINDOW

WINDOW is used to define a small portion of the image as an area of interest. The trackball cursor is used to select the endpoints of the area. Up to ten endpoints may be defined. The image outside the area is erased. The maximum area of the square enclosing the selected area is 6000 and the difference in y (vertical) must be 100 or less.

GET {HISTOGRAM}

GET returns the x, y, and z (color) of the pixel under the cursor. GET HISTOGRAM prints on the console the number of pixels of each intensity.

GRAYSCALE n

The GRAYSCALE command sets the color look-up table to be a grayscale with n levels.

FALSECOLOR n

Falsecolor sets the color look-up table to have one of the three different falsecolor types. A falsecolor look-up table is based on the method of assigning the intensities of the three colors. The look-up table is divided into four levels of intensity of the first color. Each of these levels is divided four levels of the second color. Then each of these levels is further divided into four levels of the third color giving 64 different color combinations. The order of the colors in the first falsecolor type is red, green, and blue; the second is blue, red, and green; and the third is green, blue, and red. The range of n is 1,2,3.

ZOOM [ON, OFF, ({TO} n {X})]

ZOOM activates the hardware zoom associated with the trackball cursor. 'ON' and 'OFF' place and remove the cursor on the screen. Legal values of n (the zoom power) are 0,1,2, and 8. A zero power removes the cursor. At 2X or 8X, moving the trackball allows a user to 'fly over' selected areas of the screen. When the cursor is on, a ZOOM command with no arguments will increase (if possible) the level of zoom.

TEXT, CIRCLE, LINE, RECTANGLE

The four commands TEXT, CIRCLE, LINE, and RECTANGLE are used to write titles and shapes directly on the screen. The position of the objects to be placed on the screen are given by x and y. If the @ symbol is used instead of the numbers, the user will be prompted to position the cursor to the desired placement of the object on the screen. The position values should be in the ranges of 0-639 in x and 0-479 in y. The color should be in the range of 0-63. With the exception that the text message must be last in the command string, the arguments may be in any order.

TEXT [(x, y), @] COLOR {=} n SIZE {=} m textmessage

TEXT is used to label or write a message on the screen. The position is where the upper-right corner of the message will start. Each character is normally printed in a 5x7 pixel font which may be increased by specifying a multiplication factor in SIZE. The color of the letters is specified by COLOR.

CIRCLE [(x, y), @] COLOR {=} n SIZE {=} m

CIRCLE draw a circle centered at the given position with radius specified by SIZE and color COLOR.

LINE [(x, y), @] [(x, y), @] COLOR {=} n

LINE draws a line from the first point to the second point ith color COLOR.

RECTANGLE [(x, y), @] [(x, y), @] COLOR {=} n

RECTANGLE is used to draw a rectangle of the specified color with upper-left corner at the first position and lower-right corner at the second. The color is given by COLOR.

ERASE

ERASE clears the display screen.

FUNC1 - FUNC5

FUNC1 thru FUNC5 are the commands to initiate any user defined custom functions.

STOP

STOP terminates IDBM.

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3. Operation Procedures

To keep images from different projects separate, a Data General RDOS directory is created for each project. Each directory contains only IDBM and those images associated with the project. These directories are unknown to each other and access to other directories cannot be done unless the other directories are initialized. If images from other directories are to be accessed, an

INIT otherdirectoryname

command must be given.

To run IDBM, the following procedure should be taken. The machine must be turned on. If it is not, see the next section to turn it on. If tapes are to be used, the tape should be mounted, and the POWER and LOAD switches should be pressed. When the red BOT light comes on, the ON LINE switch should be pressed. Type the following commands. A response other than 'R' indicates an error.

DIR DZ0

INIT otherdirectoryname if other directories are to be used

INIT MT0 if tapes are to be used

DIR projectdirectory

IDBM

The program is now running.

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3.1. Turn-on and -off Procedures

The entire image processing computer system is powered on and off by the following procedure.

Turn-on

Both switches in the fuse box on the wall opposite the door should be placed in the ON position.

The DC POWER rocker switch on the disk should be flipped up to ON. When the red ON light beside it comes on the DRIVE rocker switch should be flipped up to START. The WRITE switch should be in the up, ENABLE, position.

The key-lock switch on the computer panel should be turned to ON.

Both consoles must be turned on by pulling the ON-BRIGHT knobs by the side of the screens. They will take several seconds to warm up before anything is visable on the screen. The brightness of the screen may be adjusted by rotating the knob.

The Lexidata image processor is turned on by a toggle switch on its back panel.

The Conrac image display screen is turned on by pressing the POWER switch in its lower left front corner.

If any plotting is to be done the Varian electrostatic printer/plotter may be turned by pressing the POWER ON and ON LINE buttons.

Lift the RESET key on the computer panel. This is the left-most key on the panel. It will return to its normal position after being released. Make sure that the numbered keys are all in the lower position except for keys 0,11,13,14, and 15 which should be in the up position. After the red READY light on the disk drive lights up, raise the dark blue PR LOAD key on the computer panel.

FILENAME?

should appear on the console. Depress the CR (return) key on the keyboard. If the next response is:

PARTITION IN USE - TYPE C TO CONTINUE

enter a (capital) C.

The next response should be

MAPPED ECLIPSE (S/130,S/230,C/330) RDOS REV 6.30

MONTH (M/D/Y) ?

Enter the number of the current month (1-12), day of the month (1-31), and year (last two or all four digits) followed by CR. Either a space or a '/' should be used to separate the month, day, and year. It next asks for the time with

TIME (H:M:S) ?

Enter the current hour (0-23), the minute (0-59), and optionally the second (0-59) followed by CR. The response should be 'R'. Type the following lines on the keyboard. The correct response for each is 'R'.

SMEM 90

EXFG/E CLI

The system is now completely turned on and both terminals are ready for use.

Turn-off

The last remaining user may power the system down by following this procedure.

From the leftmost terminal, type

DIR DZ0

and then press both the CTRL and F keys simultaneously.

FG TERM

may be printed on the console. Next type

RELEASE DZ0

The correct system response is

MASTER DEVICE RELEASED

Turn the disk drive switch to STOP.

Turn off both consoles, the Lexidata image processor, the Conrac display screen, the Varian printer/plotter, and the computer front panel. When the disk stops moving, turn the DC power switch to OFF and turn off both switches in the fuse box.

3.2. Image Filenames

Image file names consist of a directory name header followed by the image name and a possible extension. An example file name is 'IPIN:MYIMAGE4.DP'. Alphanumerics (letters and numbers) are the only allowable characters in the file names. The directory section (IPIN in the example) is the project name where the image was created and stored. Access to that image inside the project directory IPIN may just use the name MYIMAGE4.DP as the current directory name is assumed. Users in other directories must use the full name. They must also have earlier initialized IPIN via an IDBM INIT command. A colon ':' separates the directory name from the actual file name. The filename may be up to ten characters in length. A period '.' separates the filename from a possible one or two character extension.

Images saved on disk via the IDBM SAVE command may take up several tens of thousands of bytes of disk space for storage. It is the users responsibility to keep older, unused images off the disk. One method is to save images directly from tape to one of the temporary image files IMGF1 - IMGF9 as these are deleted at the end of each session and so do not take up permanent space. Unfortunately, it also forces the user to reload his images at every session. A more reasonable approach is to leave his working images on disk until he is done with them. He may then delete the images off the disk having previously copied them to tape for future reference if they might be used again. The IDBM COPY command was included primarily for this purpose. Two Data General RDOS commands, LIST and DELETE, may be used for finding and deleting old image files. As they are not IDBM commands, they must be used only after the IDBM command STOP has been given. IDBM may be restarted by typing IDBM. The format of the LIST command is:

LIST filename

If the file exists, the name will be printed along with its size. If no file name is printed, the file does not exist.

LIST with no filename lists all files in the current directory. The special character '-' may be used if only part of the complete file name is known. For example

LIST A-.-

will list all files that start with an 'A' with any extension.

LIST -.DP

will list all files that have extension 'DP'. The files may then be deleted via the DELETE command. Its format is

DELETE filename

3.3. Tape Conversion

Since the Landsat CCT MSS tapes have had in the past several format changes and the fact that the EOD-LARSYS classification package only works on LARSYS or UNIVERSAL formatted tapes, the LARSYS format has been chosen as the Remote Sensing Project standard. All Landsat tapes must therefore be converted into the LARSYS format on the Univac mainframe. If the reformatted Landsat tapes are to be drawn with IDIMS on the image processing system, they must be built at a tape density of 800 bpi. However, a large 2400 ft. reel of tape only holds approximately half a Landsat scene at that density. Landsat tapes may be obtained from the EROS data center. For those tapes exposed prior to January 1979, they should be obtained in band interleaved format on either one 1600 bpi tape or two 800 bpi tapes. The runstream to do the conversion of these tapes is:

```
@RUN runid,accno,projectid,30
@ASG,TJH   OUTAP,16N//////Q,outputape     output @ 800 bpi
or
@ASG,TJ    OUTAP,16N//////Q,outputape     output @ 1600 bpi
@MSG,W PLEASE MOUNT outputape RING IN
@ASG,TJ  TAPE,16N//////Q,inputape         input on one tape
@ASG,TJ  TAPE,16N//////Q,input1/input2    input on two tapes
@ASG,T  CCT,//
@XQT  JSC.OTAP
area specification
```

For tapes exposed after January 1979, they should be obtained in geometrically corrected, band sequential format on two 1600 bpi tapes. The conversion runstream is:

```
@RUN runid,accno,projectid,30
@ASG,TJH   OUTAP,16N//////Q,outputape     output @ 800 bpi
or
@ASG,TJ    OUTAP,16N//////Q,outputape     output @ 1600 bpi
@MSG,W PLEASE MOUNT outputape RING IN
@ASG,TJ  TAPE1,16N//////Q,inputape1
@ASG,TJ TAPE2,16N//////Q,inputape2
@ASG,T  CCT,//
@XQT  JSC.NTAP
area specification
```

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where the area specification consists of three cards that control the conversion process.

CARD 1   On the older format the first card consists of the number of data tapes (1 or 2) in column one and any description of the area to be converted on the rest of the card. The entire card may be used for the description on the newer format.

CARD 2 Ending in columns 5 and 10 is the number of the LARSYS output tape and the file number on the output tape that the reformatted image is to be stored. The first file on the tape is numbered one (1).

CARD 3 Ending in columns 5, 10, 15, and 20 is the first line, first pixel, last line, and last pixel of the area to be converted.

4. Examples of Use

The following consists of a example IDEN session. The users commands and responses are underlined. Those lines started with an "*" are comments explaining the commands and are not actually entered into the system.

IDEN

IDEN IMAGE PROCESSOR

ENTER COMMAND

draw larsys tape 0

*A Larsys formatted tape is drawn. It has 4 channels and

*640 pixels in each scan line.

4 CHANNELS

640 PIXELS/LINE

TAPE DESCRIPTION - E-[illegible]575-15443-4

ENTER CHANNEL NUMBER 2

ENTER LINES TO SKIP [illegible]

ENTER LINES TO DRAW 480

ENTER PIXELS TO SKIP 0

ENTER PIXELS TO DRAW 640

ENTER COMMAND

grayscale

ENTER NUMBER OF GRAY LEVELS 64

*The image is not meaningful except in shades of gray.

ENTER COMMAND

save in [illegible]

ENTER DESCRIPTION

alabama strip mine, channel 2

*The image is saved on disk with the name ala2.rp

ENTER COMMAND

define imgf2 as ala2.rp

*The file ala2.rp is defined to imgf2

ENTER COMMAND

define imgf4 as ala4.rp

*the previously save file ala4.rp is defined to imgf4

ENTER COMMAND

draw imgf4

DATA SAVED 4/ 8/1980

DESCRIPTION

ALABAMA STRIP MINE, CHANNEL 4

ENTER COMMAND

draw imgf2

DATA SAVED 4/ 8/1980

DESCRIPTION

ALABAMA STRIP MINE, CHANNEL 2

ENTER COMMAND

zoom to 1x

ENTER COMMAND

window

*A training sample selection is begun.

POSITION CURSOR TO DEFINE WINDOW

HIT CR TO CONTINUE, HIT ANY KEY THEN CR ON LAST POINT

*The cursor is positioned over the 1st point.

HIT CR TO CONTINUE, HIT ANY KEY THEN CR ON LAST POINT

*The cursor is positioned over the 2nd point.

HIT CR TO CONTINUE, HIT ANY KEY THEN CR ON LAST POINT

*The cursor is positioned over the 3rd point.

HIT CR TO CONTINUE, HIT ANY KEY THEN CR ON LAST POINT

*The cursor is positioned over the 4th point.

HIT CR TO CONTINUE, HIT ANY KEY THEN CR ON LAST POINT ijk

*The cursor is positioned over the last point.

ENTER COMMAND

zoom

*A higher zoom is used to examine the window

ENTER COMMAND

get histogram

*The histogram of the window is printed.

*Note the 132 59's, the window lines.

0	305642.	1	0.	2	6.
3	1.	4	0.	5	1.
6	1.	7	1.	8	3.
9	1.	10	5.	11	31.
12	70.	13	131.	14	258.
15	243.	16	186.	17	131.
18	110.	19	96.	20	79.
21	18.	22	16.	23	10.
24	10.	25	2.	26	6.
27	2.	28	2.	29	3.
30	0.	31	2.	32	0.
33	0.	34	0.	35	0.

36	0.	37	0.	38	0.
39	0.	40	0.	41	0.
42	0.	43	0.	44	0.
45	0.	46	0.	47	0.
48	0.	49	0.	50	0.
51	0.	52	0.	53	0.
54	0.	55	0.	56	0.
57	0.	58	0.	59	132.
60	0.	61	0.	62	0.
63	0.				

```
ENTER COMMAND
get
*Reflectance values from several points are obtained.
(X,Y,Z) = (121,212,16)
ENTER COMMAND
get
(X,Y,Z) = (121,209,16)
ENTER COMMAND
get
(X,Y,Z) = (125,215,15)
ENTER COMMAND
get
(X,Y,Z) = (110,202,14)
ENTER COMMAND
draw (imgf2>13)&(imgf2<17)
*all of the image except that of intensity 14,15, and 16
*is stripped away.
```

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ENTER COMMAND

draw imgf2

*The original image is restored.

ENTER COMMAND

change 14 to 200,0,0

*Selected intensities are made more visiable.

ENTER COMMAND

change 15 to 200,0,0

ENTER COMMAND

change 16 to 200,0,0

ENTER COMMAND

change 17 to 0,0,200

*The places of intensity value 17 are shown.

ENTER COMMAND

grayscale 64

*A grayscale is put back on the image.

ENTER COMMAND

draw imgf4 1 ((imgf2>13) & (imgf2< 18))

*The selected intersities of channel 2 are shown

*against a channel 4 background.

ENTER COMMAND

stop

5. User Extensions to IDBM

IDBM was developed to demonstrate and evaluate the capabilities of the general manipulative functions. Since its design objective concentrated on implementing manipulative functions which provide a very powerful, yet generalized, foundation for geographic data processing, little effort was put into the areas of specific analysis tools. If specific analytic or manipulative capabilities are needed, two methods may be used to obtain them. The first is to add the capability directly to IDBM. The systems staff responsible for maintenance of IDBM should be consulted for this choice. The second method makes use of a provision in IDBM made especially for this purpose. The IDBM commands FUNC1 - FUNC5 are calls to dummy routines which may be replaced by individualized subroutines for custom analysis. Up to five individualized subroutines may be used at one time. They should be named SUBROUTINE FUNC1 through SUBROUTINE FUNC5.

The individual subroutines may perform their action totally independant of IDBM or they may make use of some of the system's powers. If the system is to be used the file IPIN:ACCDEF must be INCLUDEd in their FORTRAN routines. By filling the array INPUT which is defined in the included file with a command string and CALLing COMMD(error) the action will be performed. The returned error code will be zero if no error occurred and one if an error did occur. A series of string manipulation functions is provided to build the INPUT array and will be described in the following. Other routines which are directly callable from the individualized subroutines are also described. All parameters are assumed to be of type INTEGER unless otherwise noted.

5.1. String Manipulation Routines

The library file STRING.LB contains a set of Data General FORTRAN V callable routines designed for string manipulation. It consists of the following fifteen routines:

EQSTR	BRKSTR	TRMSTR
LTSTR	SPNSTR	DLBSTR
GTSTR	SUBSTR	SIZE
ATDSTR	APDSTR	PACK
DTASTR	MATSTR	UNPACK

The maximum string length allowed is 256 characters.

EQSTR(STR1,STR2)

EQSTR is a logical function that returns TRUE or FALSE depending on whether the two strings are lexically equal. EQSTR must be declared logical in the calling program.

LTSTR(STR1,STR2)

LTSTR is a logical function that returns TRUE or FALSE depending on whether STR1 is lexically less than STR2. LTSTR must be declared logical in the calling program.

GTSTR(STR1,STR2)

GTSTR is a logical function that returns TRUE or FALSE depending on whether STR1 is lexically greater than STR2. GTSTR must be declared logical in the calling program.

ATDSTR(STR,NUM,IERR)

ATDSTR is a subroutine which converts the ASCII string in STR to a integer number returned in NUM. IERR is the returned error code. Possible errors are: 0 - no error, 1 - non-numeric character in STR, and 2 - overflow in NUM.

DTASTR(NUM,STR)

DTASTR is a subroutine which converts the integer number NUM to its ASCII character equivalent which is returned in STR. If NUM is negative, STR will have a leading '-' character.

BRKSTR(STR1,STR2,STR3)

BRKSTR is a subroutine which returns in STR3 the first characters of STR1 until a character of STR1 occurs which is also in STR2.

SPNSTR(STR1,STR2,STR3)

SPNSTR is a subroutine which returns in STR3 the first characters of STR1 that is also in STR2 until a character not in STR2 occurs.

SUBSTR(STR1,BEGCH,LEN,STR2)

SUBSTR is a subroutine which returns in STR2 the LEN characters starting at character position BEGCH of STR1. If LEN is zero, the entire string starting at charac er position BEGCH is returned.

APDSTR(STR1,STR2,STR3)

APDSTR is a subroutne which appends STR2 to the end of STR1 and returns it in STR3. If arrays are used to hold the strings, STR2 and STR3 must be different arrays.

MATSTR(STR1,STR2,POS)

MATSTR is a subroutine which returns in POS the starting character position in STR1 that STR2 occurs. If STR2 does not occur in STR1, a zero is returned.

TRMSTR(STR)

TRMSTR is a subroutine which deletes all trailing blanks from the string STR.

DLBSTR(STR)

DLBSTR is a subroutine which deletes all leading blanks from the string STR.

SIZE(STR)

SIZE is a function which returns the length in characters of the string. SIZE must be declared integer in the calling program.

PACK(BUF,N)

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PACK is a utility subroutine which takes the buffer BUF containing N bytes of information stored one per word and packs them two bytes per word.

UNPACK(BUF,N)

UNPACK is a utility subroutine which takes the buffer BUF containing N bytes of information stored two per word and unpacks them to one byte per word.

5.2. Lexidata Routines

The Lexidata color graphics display processor is controlled through the use of a set of FORTRAN callable subroutines. The description of the routines supplied by Lexidata may be found in their documentation manuals. These routines are stored in the library file LXDRIX5.LB. In addition to the Lexidata supplied routines, three other routines are included in the library file. They are DSCRS, DSRLT, and DSWLT. To allow room for the addition of the trackball cursor in the Lexidata monitor, both the joystick and the 7x9 character font have been removed.

DSCRS(POWER)

DSCRS is a subroutine which activates the cursor associated with the trackball. A POWER of 1,2, or 8 puts the cursor on the screen and a zero POWER removes it. A 2 or 8 POWER activates the hardware zoom function to the indicated power certered on the cursor.

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DSRLT(ADDR,NP,BUF)

DSRLT is a subroutine which reads NP bytes of the color look-up table starting at address ADDR into the buffer BUF. This is a corrected version of the Lexidata supplied routine DSLRD.

DSWLT

DSWLT is a subroutine which writes NP bytes into the color look-up table starting at address ADDR from the buffer BUF. This is a corrected version of the Lexidata supplied routine DSLWT.

5.3. Miscellaneous Routines

Additionally there the following routines which may be called directly from the user's program without having to build a command string.

DHIST(VAL)

DHIST is a subroutine which prints on the console a density distribution of the image being displayed. If VAL is less than or equal to zero a histogram is also drawn at the bottom of the image.

EXPAND(CH1,CH2)

EXPAND is a subroutine which takes the image file previously opened on channel CH1 and expands it on a file previously opened on channel CH2 to have a format of a one disc block header and the image stored one pixel per word.

The source image must have been built via a SAVE command. This routine is usually used to convert an image stored in a space efficient storage method to one of fast access.

RANDU(ARR,NUM)

RANDU is a subroutine which returns NUM randum numbers in the real array ARR. The numbers are in the range 0 - 1. ARR(1) is assumed to initially contain a seed value for the randum number generator.

5.4. Adding User Routines

After the user's routine have been written according to the specifications as stated above, they must be compilied and linked with IDBM before they may be used. The are compilied by the statement:

FORTRAN filename   IPIN:ACCDEF not included.

or

FORTRAN/I filename   IPIN:ACCDEF included.

They are then linked according to the following statements:

```
RLDR IPIN:MAIN ^
IPIN:<COMMD,DEXP,DEFF,DHIST,SAVE,PLOT> ^
IPIN:<ZOOM,GRAYS,FALSE,RELEASE,FIN> ^
IPIN:<CHANGE,PSCOL,NTRAN,ENHANCE,COPY> ^
IPIN:<LARSYS,SHIFT,EDIM> ^
IPIN:<RESTOR,DSRST,DSSAV,EVAL,FILL> ^
IPIN:<OPER,DCL,RANDU,NF,EXPAND> ^
**Put any user routines, FUNC1 - FUNC5 here
```

```
IPIN:FUNC.LB ^
STRING.LB LXDRIX5.LB UNIPCT FORT5.LB ^
20/C IPIN:IDBM.SV/S
```

6. Implementation Notes

I/O Channels

The following lists the FORTRAN I/O channel unit numbers used in IDEM and their use.

5,6	Console input,output (formatted)
10,11	Console output,input (unformatted)
12	Plotter
20	Overlay file
21	Temporary disk accesses
22	Temporary tape accessed
30	Temporary disk accesses
31-39	IMGF1 - IMGF9

Image Disk Storage Structures

Image are stored on disk with a one block header and a series of image data blocks. The first word on the header tells the image compaction method. Currently there are only two methods used. They are: 0 - images stored one pixel per word, and 1 - images stored in a run-length method with the first ten bits in each word for the run count and the last six for the data value. Words two through four of the header contain the month, day, and year that the image was stored. Words five through forty-five contain an ASCII string description of the image. Words 46 through 237 contain the red, green, and blue color look-up tables. The image data blocks contain the image stored by rows left to right, top to bottom, in the specified format. If new image compaction methods are to be added, they should be given the next storage number (currently 2) and sections for the encoding and decoding method should be added to DSSAV and DSRS1. The routine SAVE should also be modified to select which storage compaction routine should be used.

APPENDIX V

Geographic Data Base Image Processing at Mississippi State

by Rena A. Haynes, Mississippi State University

Introduction

A geographic image as stored in a computer is simply data that can be processed to array form which, when displayed, represents a two- or three-dimensional image. Generally, several images, related by a common geographic location, are needed to provide end users, that is, persons involved in cartographic, land management, and other geographic applications, with adequate information. The reasons for maintaining related geographic images in a common data bank are much the same as those for storing any related data in such a form. The need to access several images at one time dictates the need for centralized storage. Also, an image data base allows independence of image processing functions from image data while at the same time reducing the overhead associated with maintaining multiple files.

Operations performed on an image data base are much like operations performed on any data base. The data must be maintained and updated; queries answered; hard copy reports generated. However, processing an image data base is necessarily different from processing a non-image data base primarily due to the fact that the basic unit of an image data base is an image, a visual form of information. While image components, that is,

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pixels, or cells, and scanlines, or rows or columns of cells, may be individually accessed and processed, they are not meaningful taken outside the context of the image. Most operations on an image produce another image. In this sense traditional data base software is not easily adaptable to processing an image data base.

To effectively utilize the image data base, an image processing system, preferably interactive, should provide update, display, and hard copy functions. The update function must provide the ability to add, delete, and replace data base images as well as edit or change an existing data base image. This function allows a dynamic data base which provides decision makers with up-to-date information. The display capability, manipulating and displaying any set of data base images, is perhaps the broadest defined and most important function. This function supplies the means for answering user queries to the data base, and as such, it is the most utilized function in the data base image processing system. The hard copy function, producing a printed or plotted output of any image, provides for the ease of transporting information as well as a permanent record of information.

Implementation of a data base image processing system is dependent to a certain extent on hardware configurations. At Mississippi State University the image processing facility consists of a 640 by 480 raster scan color t.v. monitor controlled by a monitor routine resident in a Nova 3 microcomputer and provides the capability of displaying up to 64 different colors at one time. The image processing system is connected as a peripheral to a host Data General Eclipse S130 with 256k bytes of main memory. Also peripheral to the Eclipse are a 96 megabyte disc, a 9-track 800 b.p.i. tape drive, and a Varian electrostatic printer/plotter.

Display Functions

The dislay function for a geographic data base image processing system includes both capabilities basic to any image processing system and higher level capabilities which process the image data both prior and subsequent to utilizing the basic display functions. The basic functions include capabilities, such as drawing or displaying point, line, or array data; zooming or windowing in on the current display; changing the color or tone of an image segment in the current display; retrieving point, line, or array data from the current display; etc. While the basic image processing functions are necessary for the geographic data base image processing system, the primary concern of this discussion is the higher level functions which are responsible for processing image data in order to respond to user queries. These higher level functions include: 1) the capability of overlaying, or combining, data base images or image subsets, where an image subset is defined to be any image segment included in a particular gray level range; 2) the capability of logically manipulating data base images and/or image subsets; and 3) the capability of determining a proximity, or distance, from any image segment.

Overlaying Images

Overlaying images can be broken down into two categories. First, a user might wish to overlay or combine any number of data base images or image subsets. In this case the selected images must be retrieved from the data base, combined into one image, and finally displayed.

The retrieval of data base images is accomplished by an independent I/O routine which returns a buffer containing a scanline of each selected image. Initially, the input routine performs a read to determine pointers, contained in a header record, to the first line of each selected image. Next a read is performed to retrieve the first scanlines. Once the correct images are located, a link is maintained to the next scanline of each image. Before returning, the routine consecutively fills a buffer with the selected image scanlines.

After the retrieval process, an output buffer is built to contain a scanline of the combined image. First, the buffer, initialized to zero, is filled with the scanline of the first data base image selected. Subsequently, each nonzero element, or if the user specified a subclass range, each element within that range, of each succeeding data base image scanline is offset by a constant factor and placed in the appropriate buffer cell.

Finally, the buffer is displayed, the input routine is recalled, and the display buffer is reinitialized to zero. The cycle is continued until the number of lines displayed is equal to the number of lines in a data base image.

The second overlay operation consists of overlaying a current display with any combination of data base images or image subsets. In this case, instead of initializing the display buffer to zero, it is initialized by retrieving the appropriate scanline from the display. The rest of the procedure is the same as the first overlay operation. The overlay process using a 4 by 4 matrix to represent an image is illustrated in the following example:

Image 1	Image 2	Image 3	Result
1 2 10 2	0 3 0 0	0 0 0 0	1 18 10 2
2 2 10 5	3 0 0 0	1 1 1 1	31 31 31 31
2 10 5 5	0 3 0 0	0 0 0 0	2 18 5 5
10 10 5 5	0 3 0 0	0 0 0 0	10 18 5 5
(15*0 offset)	(15*1 offset)	(15*2 offset)	

Logical Manipulation

In many instances no single image maintained in a geographic data base contains all the information needed by the user. On the other hand, an image may contain more information than is required or desired. Many times the appropriate information is obtainable through a logical manipulation of data base images.

Sometimes the information is contained in several data base images or image subsets. In this case the capability of producing an image that contains the union, or OR-ING, of data base images is needed. An OR-ING of two images represented by 4 by 4 matrices is exemplified by the following:

Image 1		Image 2		Result
1 0 0 2		0 1 1 0		1 1 1 1
1 0 0 2	OR	0 1 1 0	=	1 1 1 1
1 0 0 0		2 0 0 0		1 0 0 0
1 0 0 0		0 0 1 1		1 0 1 1

At other times the information requested is contained in the intersection, or AND-ING, of data base images or image subsets. The following example illustrates the AND-ING operation:

Image 1		Image 2		Result
1 1 0 0		0 0 1 0		0 0 0 0
0 0 1 1	AND	0 0 1 1	=	0 0 1 1
0 0 0 0		0 0 1 0		0 0 0 0
0 0 1 1		0 0 0 1		0 0 0 1

Another function, having precedence over the other two, is needed to segment and regroup data base images in order to omit information unnecessary for the immediate query and to combine subsets that form one logical set in the current query. An example of this operation is shown below:

Image	Seg & Regroup of Image Segment < 4
1 1 5 5	1 1 0 0
1 2 5 5	1 1 0 0
2 2 5 5	1 1 0 0
2 2 2 5	1 1 1 0

The implementation of these logical functions require software to 1) interpret user queries, 2) encode user queries into executable commands, and 3) execute encoded commands.

Since user queries to the geographic image data base should be input in as much a natural language form as possible, an interpreter to syntactically parse and semantically analyze the query is desirable. One method to accomplish this is through a transition network which analyzes a user command in a top down, left to right fashion. The input is broken into tokens in a scannar routine which passes them, one at a time, to a parsing program which determines if the token will allow a transition from the current state to another state. If there is no transition with the current token, the syntax analyzer outputs an error message containing information about what tokens are allowable in the current state and returns control to the user for another command. If an allowable transition exists, the parser takes that transition and calls a semantics routine which generates an internal code to be executed upon completion of a successful parse.

All tokens except general delimiters, such as blanks and commas, generate internal code since even the designation of a data base image requires a retrieval operation at execution. The general form of a user command, where brackets signify optional tokens, is

Image{Seg & Regroup}{AND/OR OP Image{Seg & Regroup}}*{End Val}.

Data base images are designated via acronyms maintained in a descriptive file or through image code specification. Image segmentation and regrouping operations are indicated by either relational operators, such as, equal, not equal, less than, less than or equal, greater than, greater than or equal, followed by a numeric value or by specification of subclasses. The AND and OR operations are specified by the keywords "AND" and "OR" respectively or by special symbols "$\wedge$" and "V". An ending value which is used to set the result of an operation to a value other than the default value, is specified by the keyword "EQUAL" followed by a numeric value. Several logical manipulations can be specified in a single command with the order determined in a left to right manner unless otherwise denoted by parentheses. An image can also be produced iteratively, using the display as intermediate storage.

Once the input has been parsed, the scannar returns a special image which signifies the end of a user command. The semantic action associated with this image is to encode a stop command and call a routine to execute the encoded command buffer.

The execution stage is responsible for retrieving appropriate images, segmenting and regrouping an image where specified, performing the AND-ING or OR-ING operation, and displaying the result, one scanline at a time. If more than one operation is specified, the result is used as an operand for the next operation. When operations are grouped by parentheses, the execution recursively determines the result of the operation in parentheses.

Proximity Operation

Occasionally, the fact that certain pixels in an image contain a particular value is not as important as the pixels within a certain distance from those pixels. This proximity, or distance, information may be needed for any data base image subset or any result of a logical operation. Therefore, it is appropriate to consider this function as an operation upon a displayed image.

Distance can be defined in a four- or eight-cell neighborhood context. The four-cell neighborhood of a pixel contains cells horizontally or vertically adjacent to that pixel, while the eight-cell neighborhood also includes cells diagonally adjacent to that pixel. Implementations of both four- and eight-cell neighborhood distances generally require the use of intermediate storage.

At Mississippi State the geographic data base image processing system includes an implementation of a four-cell neighborhood proximity operation. This implementation uses the raster scan display refresh memory as intermediate storage. A maximum distance of nine cells is considered relevant so that any cell that is more than nine cells away is still given a distance value of nine.

Initially, the user is prompted for the intensity value (between 0 and 63) of the image segment upon which the distance operation is to be performed. If this intensity value, or object value, is less than ten, the image is preprocessed left to right, top to bottom changing the value of any cell equal to the object value to that value plus ten and changing the value of any cell equal to the object value plus ten to the object value; finally, ten is added to the object value.

Once the object intensity value is determined, the image is processed two scanlines at a time first from top to bottom then from bottom to top. Initially, the first scanline is processed with a buffer whose elements have a value of nine and a counter initialized at 9. Next the second scanline is retrieved and processed wtih the first and so on until the last scanline has been processed. The top to bottom stage is accomplished by processing each scanline pair from top to bottom, then left to right, then right to left changing any cell whose value is equal to the object value to zero at the same time changing the counter to the new cell value and then incrementing the counter by one to a maximum of nine, indexing into the next cell, and setting the cell value to the counter if the cell value is greater than the counter. If a cell has a value less than the counter, the counter is set to that value. A default value of nine is given to any cell for which a distance value cannot be determined in the first stage.

The second, or bottom to top, stage is accomplished by initially processing the last scanline with a buffer whose elements have a value of nine and a counter initialized to nine. Then the next to last scanline is retrieved and processed with the last in a bottom to top mannar. The procedure for processing the image from bottom to top is the same as the procedure for processing the image from top to bottom with the exceptions that the scanlines are processed only in a bottom to top manner and no default values are set. Upon completion of the second stage, the current display contains the proximity image. An example of the proximity process with the object intensity value set at ten is given below:

Initial Image	1st Top to Bottom Pass
10 0 0 0	0 9 9 9
10 10 0 0	0 0 9 9
10 0 0 0	10 0 0 0
10 10 10 0	10 10 10 0

Left to Right				Right to Left			
0	1	2	3	0	1	2	3
0	0	1	2	0	0	1	2
10	0	0	0	10	0	0	0
10	10	10	0	10	10	10	0

End of Stage 1				1st Bottom to Top			
0	1	2	3	0	1	2	3
0	0	1	2	0	0	1	2
0	1	2	3	0	1	1	2
0	0	0	1	0	0	0	1

End of Stage 2			
0	1	2	3
0	0	1	2
0	1	1	2
0	0	0	1

Update Functions

The methods used to update an image data base are dependent to a great extent on the physical structure of the data base. Since an image in array form can have a large storage requirement, the need for procedures to minimize this storage requirement is important, especially when centralized storage of several images is desired. Another important consideration because of the need to access several data base images in one operation is the enhancement of a mode of making multiple logical accesses to the data base with one physical access. These considerations are important in the geographic image processing system at Mississippi State.

One method to reduce storage requirements is to store consecutive pixels whose values are equivalent as a run, specifying only the length and intensity value of the run. This runlength code is relatively simple to implement and is easily expanded for many image processing functions, especially the display functions. One way to facilitate the multiple access mode is to physically store images in an interleaved fashion in which the top scanlines of all the images are stored consecutively followed by all of the second scanlines and so on. Each scanline pertaining to the same image is connected via a link which points to its succeeding scanline. The initial scanline of an image may be found by a search of the first input buffer or through pointers maintained in a header record of the data base. The header record also contains other information needed to process the data base as well as descriptive data. In particular, the other information needed for processing includes the maximum number of images in the data base, the maximum number of scanlines in an image, and the maximum number of pixels in a scanline.

While this physical structure facilitates the display functions as well as reducing storage requirements, it makes the task of updating the data base somewhat complex. To simplify the update function, subfunctions are defined narrowly. Specifically, the subfunctions in the geographic data base image processing system at Mississippi State are ADD, DELETE, REPLACE, CHANGE, and DIGITIZE.

The add subfunction is defined as incorporating the image currently being displayed as the last image in the data base. Since the data base is stored in an interleaved form, this addition requires a change in each scanline link except those maintained in the header and the null pointers contained in last scanline of each image. Consequently, the data base is rewritten, changing link values as well as adding the new image. Prior to the first data write, a header record containing the new descriptive data, pointers to the initial image scanlines, including the new image, and the image processing information is written to the new data base file.

The delete subfunction is defined as the removal of a current data base image. Unlike the add subfunction, deletion does not require a display; however, deletion does require scanline links to be changed, and like the add subfunction, delete requires the data base to be rewritten.

The replace subfunction is defined as the removal of a current data base image and the addition of the current display in place of that image. Conceivably, this subfunction could be executed without requiring that the data base be rewritten since the number of scanline runs in the new image could be equal to or less than the number in the current data base image. However, to maintain the integrity of the scanline links and minimal storage requirements, the data base is rewritten.

The change subfunction is defined as the interactive update of image segments within a data base image that is being displayed. The implementation of this subfunction allows the user to first specity the data base image he wishes to change, next to specify whether he wishes to change point or area image components, and finally to change values associated with the image component he has selected.

If an area image component has been selected, the user identifies the window area by use of a trackball and a screen cursor. The software then copies this window to an unused portion of the display. Within this new area image component values can be changed. At any time the user can decide to define a new window in the original image, in which case the previous display area is erased, or to replace the window as it has been changed. Once the image has been changed, the user must use either the add or replace subfunction in order to place the new image in the data base.

The digitize subfunction is defined as the addition of pixels defined by digitized data to the current display. This subfunction requires the capability of automatically generating data base x-y coordinates for the pixels defined by the digitized data which is input from a file separate from the data base. As the x-y coordinates of the pixels are determined, the corresponding image cells are given a value that has been previously defined by the user. As in the change subfunction, to include the resulting image in the data base, the user must initiate the add or replace subfunction.

Hard Copy Function

The hard copy function is important in any image processing system in order to assure a portable physical record of image information. This function is supplied in the geographic data base image processing system at Mississippi State by software which accepts the current display as input and processes this input, several scanlines at a time for output to the electrostatic printer/plotter. This procedure retrieves scanlines from the raster scan display refresh memory, maps the scanline pixel values onto corresponding plotter intensity values, and initiates a binary write of the resulting data to the plotter.

Conclusion

When several images are required to supply information, a data base system provides an efficient and effective means of processing this data. We have concentrated here on a particular implementation of a geographic data base image processing system. Like most data base systems, the geographic data base image processing system includes software to update and maintain data, to respond to user queries, and to produce hard copy reports.

Because of the large storage requirements in both image processing functions and image maintenence, methods to reduce storage requirements have been included; however, at the same time consideration is given to methods of achieving efficient processing as well as efficient storage.

APPENDIX VI

STATUS OF SUITABILITY MODEL FOR USE BY THE MISSISSIPPI STATE HIGHWAY DEPARTMENT

INTRODUCTION

During 1979, Dr. W. Frank Miller contacted the Mississippi State Highway Department to discuss the use of remote sensing in the environmental evaluation of alternative highway locations.

An agreement was reached to study the proposed U.S. Highway 78 corridor east of Fulton to the Alabama/Mississippi State Line. This area had previously been assessed under the Department's normal environmental processes and discussed in the Environmental Impact Statement (1975).

At the time Dr. Miller initiated the remote sensing project, the highway design studies were in an advanced stage of development. In fact, several weeks prior to Dr. Miller's initial contact with the Department, personnel had completed a Plans-In-Hand field inspection.

This inspection had revealed the possibility of design modifications in order to attempt to minimize wetland involvement within the Bull Mountain Creek floodplain.

Dr. Miller's use of remote sensing and suitability modeling appeared to satisfy a need for a tool to use in additional evaluation.

METHODS

The basic technique is described in detail in "Rational Land Use Decision-Making: The Natchez State Park" (1979).

Although the method is probably best used in the environmental assessment of large land areas at initial stages of project development, it was felt that for the purpose of demonstrating the overall utility of the method, Dr. Miller should have full latitude in the assessment.

Accordingly, the Department furnished all elementary information requested for development of the model. The selection of variables and suitability ratings used in the data base information system was left to Dr. Miller and an interdisciplinary team created by him.

This procedure assured the minimization of bias and full consideration of environmental components.

RESULTS

It was recognized that the results of the method were not, in themselves, a decision but rather a tool to be used in the decision-making process. The computer model would indicate areas of potential lowest impact of those variables selected. However, economic, engineering and certain other environmental criteria would require separate application in the decision-making process.

Following the completion of the suitability model and computer runs, Department environmental personnel met with Dr. Miller to discuss the results.

The Department has been pleased not only with the application of the method to large area assessment, but also with the utility of the method for smaller areas.

Although the study area was small and had previously been assessed through photographic analysis and on-site evaluation, the graphic portrayal of environmental suitability can lend much to the decision-making process.

FUTURE CONSIDERATION

Dr. Miller's ultimate contribution to the method is technology transfer rather than contract consultive in nature. This approach favors consideration of the method in application to highway development.

The test of effectiveness and eventual use by Department-trained personnel will depend upon the acceptance of the method by the public and by Federal and State Agencies resposible for environmental review and evaluation of highway projects or components of highway projects.

The use of the method on a small scale may be tested shortly by the Department in its coordination with Federal and State Agencies on wetland issues.